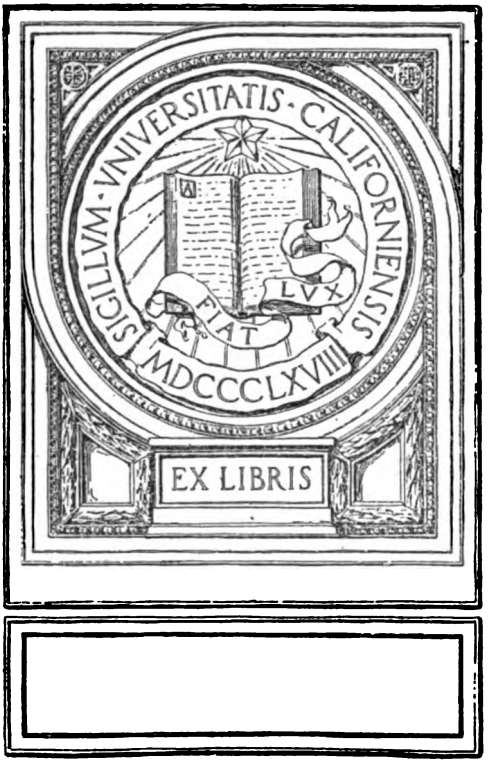

THE LAW OF BIRTHS & DEATHS

THE LAW *of* BIRTHS *and* DEATHS · BEING A STUDY OF THE VARIATION IN THE DEGREE OF ANIMAL FERTILITY UNDER THE INFLUENCE OF THE ENVIRONMENT · *By* CHARLES EDWARD PELL

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PREFACE

THIS little work, as its title suggests, is an attempt to place the problems of animal fertility and the birthrate on a more scientific footing than they have hitherto held. It endeavours to show that the decline of the birthrate cannot be explained on the hypothesis that it is due to the deliberate evasion of child-bearing; but that it can be explained as the result of a natural law the function of which is to adjust the degree of fertility to suit approximately the needs of the race.

The accepted theory cannot, by any stretch of ingenuity, be made to account for many of the most significant features of the birthrate problem. It cannot account for the vast and increasing proportion of completely sterile marriages among the intellectual classes in all countries, among the British nobility, and among the wealthy classes generally—unless, indeed, its advocates are prepared to make, without a particle of reliable evidence in its support, the remarkable assumption that anything up to 25 per cent. of these classes take the most elaborate and troublesome precautions, from the very marriage eve, to avoid having a single child. It cannot account for rises in the birthrate such as took place during the early part of last century in England and recently in Japan. It cannot account for the seasonal fluctuations of the birthrate. It ignores the fact that the use of contraceptives involves the most elaborate and troublesome precautions at a time when the parties

concerned are least in the mood for such precautions, and assumes that the readiness to adopt these precautions increases in direct proportion with the absence of the need for them; while the desire to avoid having a single heir is assumed to increase steadily with the acquisition of wealth and position which should, apparently, tend to make the arrival of an heir desirable and keenly desired.

On the other hand, all the phenomena of the fluctuating birthrate may be satisfactorily explained as the effects of a natural law, the action of which can be clearly traced among unicellular organisms, throughout the vegetable and animal kingdoms and throughout human society.

It is true that commissions have sat in Australia, France and England to investigate the problem, and that their reports have been in favour of the accepted view; but the blight of preconceived opinions was upon all their works. The National Birthrate Commission in this country, for example, had before them ample evidence in support of the view that there has been a vast decline in fertility due to natural causes; while the evidence upon which they based their report in favour of the opposite hypothesis is quoted in this work as providing the strongest possible confirmation of the interpretation they rejected. It is a mistake to suppose that an individual acquires as a commissioner an analytical faculty and sound judgment as to the value of evidence which he did not possess in a private capacity—that one who has shown no aptitude for grappling with a problem in the latter rôle acquires the necessary capacity as soon as he assumes the former. Fifty indifferent cooks will not make one good cook. Fifty mediocre musicians do not, when taken collectively, constitute a great artist. And to gather together forty or fifty individuals, not one of whom has shown the ability to deal with the

problem singly, is not the way to solve it. A wholly exaggerated importance is attached to the reports of commissions.

The conception that the fluctuations of the birthrate are governed by a natural law, and that luxurious conditions are unfavourable to fecundity, is not new. Saddler, in particular, in his work, *The Law of Population*, brought together a considerable body of evidence in support of this view, and quoted in its favour the testimony of Hippocrates, Herodotus, Aristotle, Bacon, Rousseau, Adam Smith and other notable men. Even before Saddler, many medical men, among others Dr. Short, Dr. Black, and Dr. Buchan, were alive to the fact that, as Bacon had put it, "Repletion is an enemy to generation," or, in Dr. Black's words, that "high refinement is an obstacle to propagation."

Saddler summarises Dr. Short's views, as set forth in his work, *New Observations, etc., on Bills of Mortality, etc.*, as follows: "He asserts over and over again, and throughout his whole work, that poor food and hard labour are conducive to prolificness, and consequently that 'the poorest and most laborious part of mankind,' to use his own words, 'are the fruitfullest.' He even carries this idea so far as to conclude that the most laborious and toilsome months of the year are the most fruitful of conceptions, and attributes the great fruitfulness of the Israelites in Egypt, as a secondary cause, to their bondage and affliction. He explains the inferior fecundity of town breeders as compared with those of the country as arising, among other things, from the more plentiful eating and drinking, and the greater idleness, which prevail in populous towns, observing that the most voluptuous, idle, effeminate and luxurious are the barrenest; and he delivers what I believe to be an

incontrovertible axiom, that though 'idleness may be a friend to venery, it is not so to prolificness.'" (*The Law of Population*, vol. ii. p. 579.) Seeing that Dr. Short's work was published as far back as 1750, this is sufficiently noteworthy. But Short offered no explanation of the mechanism by which these results are brought about.

Saddler summed up his own views as contrasted with those of Malthus and his followers in the following passage: "They contend that production precedes population; I, on the contrary, maintain that population precedes, and is, indeed, the cause of production. They teach, that man breeds up to the capital, or in proportion to the abundance of food he possesses; I assert that he is comparatively sterile when he is wealthy, and that he breeds in proportion to his poverty: not meaning, however, by that poverty a state of privation approaching to actual starvation, any more than, I suppose, they would contend that extreme and culpable excess is the grand patron of population. In a word, they hold that a state of ease and affluence is the great promoter of prolificness; I maintain that a considerable degree of labour, and even privation, is a more efficient cause of an increased degree of human fecundity." (*The Law of Population*, vol. ii. p. 570.) Saddler's work was published in 1830, when the birthrate was rising.

Quoting such evidence as that provided by the failure of the peerage to reproduce itself, Saddler furnished a very effective refutation of many of the conclusions of Malthus; but he failed to offer any explanation of the mechanism by which the law operates, and he embodied his own conclusions in the assertion that "fertility varies inversely as the density of population." The transparent absurdity of this formula delivered him as an easy prey

to Macaulay, who took advantage of the opportunity with his usual ruthlessness and lack of any sense of fair play where his preconceived ideas and middle-class prejudices were concerned. Saddler brought together a bulky, and in some parts valuable, body of evidence bearing on the subject in his two volumes, but his formula does not call for extended criticism.

The best hypotheses yet put forward in the effort to explain the law governing fertility, known to the writer, are those of Doubleday and Herbert Spencer. They are analysed and criticised in the body of this work.

During later years a hypothesis has been developed by Dr. John Brownlee that the declining birthrate is the result of a recurrent fluctuation of "germinal vitality." His theory is that there are vast periodical fluctuations of fertility, and that periods of high fertility, which he identifies with periods of high germinal vitality, are accompanied by the birth of large numbers of great men; while during periods of low germinal vitality, or low fertility, great men are rare. Dr. Brownlee illustrates the theory with a large body of interesting facts and statistics. The weaknesses of the hypothesis lie chiefly in the facts that there is very little reliable evidence bearing upon birthrate fluctuations in past ages, as periods of racial expansion are not necessarily due to a high birthrate; that estimates of the relative greatness of the men who appear at different epochs are largely a matter of individual taste, "greatness" being, in a large proportion of cases, merely the result of exceptional luck in the advertising line, or "the flatness of the surrounding country"; that the theory is not a necessary deduction from the principles of organic evolution, its relation to which is not explained; and that it offers no clue to the mechanism which controls fertility.

Any hypothesis put forward as an explanation of the laws which regulate fertility should be a deduction from the principles of organic evolution, since the degree of fertility is one of the most potent factors governing the survival and evolution of species. It is obvious that there has been a steady decline of fertility from unicellular organisms up to man, and we may, therefore, ask ourselves: To what law, or laws, must the degree of fertility have conformed in the past to produce the results we see?

But to obtain by deduction a hypothesis which satisfactorily covers all the facts is not an easy matter. For if it be asserted that good feeding and improved surroundings generally are conducive to high fertility, a multitude of facts can be quoted in support of that view and also against it. And if it be argued that hard conditions are favourable to fertility, an equally imposing body of facts can be quoted both for and against. The evidence, indeed, seems to be a hopeless mass of contradictions and inconsistencies. Yet I trust that the difficulty has been successfully overcome in this work by applying to fertility the principle of the vital optimum, and distinguishing between fluctuations due to the several factors: seasonal instincts, sexual fertility, asexual fertility and ovulation. It has been the lumping together in the past of the varying response of these several factors to the same conditions which has been largely the cause of the apparent confusion. When the governing abstract principles are accurately stated, the evidence falls readily into line.

This is not a history of the birthrate problem, and it has not been thought necessary to go at length into those aspects of the problem already fully dealt with in other works and worn threadbare by discussion. The non-

essential parts of the problem have been dismissed as briefly as possible in order to economise space for the main purpose of the work.

Among the most puzzling facts of anthropology and history have been the small apparent advance in intellect made by the human race during thousands of years, and the invariable decline of ancient races after reaching a high pinnacle of wealth and civilisation. The facts cease to be very mysterious, however, in the presence of a law which causes the birthrate to decline with the deathrate, and renders the race sterile when a certain stage of development has been reached. Humanity has been likened to a candle which perpetually burns away at the top and is renewed from below. It is obvious that, if this is so, progress beyond a certain level will be impossible unless the difficulty be grappled with, the obstacle to further evolution overcome, and an intelligently regulated birthrate among the abler sections of the community secured. It is time that the matter was thoroughly threshed out.

The problem of the declining birthrate is now a critical one for the French nation. In a decade or so, at the present rate of progress, we shall have reached the point where France stands now. So it behoves us to make up our minds whether we will initiate an intelligently directed inquiry, determined to leave no stone unturned to solve the problem, or persist in barking up the wrong tree until our civilisation crumbles beneath our feet. The whole future of the human race depends upon the solution of the problem of the birthrate and population. Compared with it, troubles in Ireland, unemployment, or even such events as the recent great war, are merely passing ripples on the surface of our civilisation. It is a problem which has interested every great thinker upon

social questions, from Plato and Aristotle down to Darwin and Herbert Spencer.

Failure to grapple with it successfully seems to have been the chief cause of the decline of many ancient empires, the names of which have come down to us out of the remote past, or whose remains still lie scattered over the surface of the earth. This was almost certainly the case with Ancient Rome and Greece, for even where there has been no actual decline of population there has been a replacement of the homogeneous native race by a heterogeneous collection of aliens. Neither of these alternatives can be contemplated by a high-spirited nation with equanimity; yet either may overtake the leading nations of the world within a measurable period unless the problem of the birthrate be successfully grappled with. This work will have fulfilled its purpose if it assists inquiries directed towards that end, and if the problem is brought one step nearer solution.

I would like to express here my obligations to Dr. Halford Ross, Dr. John Brownlee, and Dr. Leonard Hill, who have been among the foremost in pointing out the inadequacy of the "race-suicide" theory to explain the facts, and to whom I am indebted for valuable help in various ways. They are, of course, in no way committed to the particular theories and interpretations expounded in this work. Also I am indebted to old friends—in particular to Mr. Horace F. Bastings, Mr. W. H. Trimble, and Mr. G. Richardson—in Dunedin, New Zealand.

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CHAPTER I

RACE SUICIDE OR A NATURAL LAW?

So accustomed are we to the small families usual in the more prosperous European countries, that we seldom realise how vast is the gap which separates the full potential fertility of the human race from its actual or realised fertility. A family of five or six is looked upon as quite large in England, while a family of ten or a dozen is regarded as enormous. Yet the average family among the French-Canadians is said to be over nine, and Dr. C. E. Woodruff asserts that there are fifteen to twenty births per family among the Philippinos even yet.[1]

The period of potential fertility among the women of civilised communities is from fifteen to about fifty years. A rate of even one child per annum would thus give a potential fertility of about thirty children for a woman who married before twenty and lived until past fifty years of age. Nor is this the full story. "Aristotle mentions a woman who had five children at a birth four times successively; Menage one who had twenty-one children in seven years."[2] Mulhall also mentions one

[1] *Expansion of Races*, Woodruff, p. 177.
[2] *Dictionary of Statistics*, Mulhall.

woman who had fifty-seven children; another who had sixty-nine; and a third who had fifty-two, "never less than three at a birth." Yet, "according to Bertillon and other authorities, the European average shows that 100 married women will have in their life 420 children,"[1] or an average of 4·2 per marriage. To what is this enormous difference between the potential fertility and the actual fertility of the race due?

There are, of course, many incidental causes, such as late marriages and early deaths, diseases and various peculiar customs among many races; but such causes go only a trifling way towards explaining the vast difference. As regards disease, there is no ground for believing that those diseases which are most likely to cause sterility are more prevalent now than they were when the birth-rate was at its highest, so that factor as a possible explanation may be dismissed.

Apart from merely incidental factors, we may assume the difference between the potential and the actual fertility of the race to be due to one of two causes: a natural law which regulates the degree of fertility to suit approximately the needs of the race, or evasion of child-bearing by artificial methods. The second of these is the explanation usually adopted.

During the first three-quarters of last century the birthrate was substantially higher than it is at present, although it was, even then, only a fraction of the potential fertility of the race. Then, as now, the largest families were produced among just those classes which could least afford to rear them, and the inevitable hardships which resulted led to the formation of the Neo-Malthusian League, the express purpose of which was the dissemination of information as to the means by which excessive

[1] *Dictionary of Statistics*, Mulhall.

child-bearing might most readily be avoided. Into the controversy which has raged as to the desirability of spreading such information it is not necessary to enter here.

It so happened that just about the time that the Neo-Malthusian League propaganda in England was getting well under way—about the year 1876—the birthrate began to decline. Drs. Newsholme and Stevenson find that the decline began generally about 1876, and is much the same for all the countries studied.[1]

Naturally, such a coincidence has led to a belief that the decline is due to deliberate restrictive measures. Yet the decline has been continuous in France for a century or more, and vast fluctuations of the birthrate—increases as well as decreases—have occurred, and still occur, even in countries where the influence of that league is unknown. Under Francis I French families averaged seven children; under Louis IV, five; in 1789, four; in 1890, three; and by 1914 the average had declined to about two.[2] Malthus quotes M. Necker and M. Muret, showing that the demographic phenomena in both France and Switzerland were exactly the same at the end of the eighteenth century as now, the poorer districts being much more fertile than the richer.[3] As will presently be shown, it is very probable that the coincidence between the commencement of the decline of the birthrate and the activities of the Neo-Malthusian League in England was merely due to the fact that the same development of education and intellectual activity which led to the decline led naturally to speculation as to the means by which large families could be avoided.

[1] *Expansion of Races*, Woodruff.
[2] *North American Review*, December 1919.
[3] *The Principle of Population*, Book II, chap. v, and Book IV, chap. v.

Moreover, we find that, although the poorest classes have the least means available for rearing children and the strongest reasons for avoiding them, it is they, nevertheless, who have the largest families; while the wealthiest classes, who have no lack of means for rearing children, have the fewest, and a large proportion of them with large fortunes and titles to transmit to their heirs are childless. It is attempted to explain these facts by "the theory of social capillarity." As people become more highly educated, it is argued, and advance in life their wants and ambitions expand, while the struggle for social prominence grows ever keener. They display more prudence and foresight, and this results in the careful limitation of the number of their children. There is an element of truth in this; but if the decline in the birthrate were due to such causes, we should expect to find the smallest families among the lower middle classes, who have to fight most keenly for a place in the sun, and who are certainly not lacking in prudence or foresight where their worldly interests are concerned. But the lower middle classes have larger families than the very wealthy. Statistics by the most reliable authorities show that the degree of fertility declines steadily from the very poorest classes to the very richest, and that the smallest families are found among the most wealthy people, to whom the theory of social capillarity has no real application.

A fallacy which can be briefly dealt with and dismissed is the belief that religion powerfully affects the birthrate. It has been asserted that the Roman Catholic Irish are very fertile because their religion forbids the restriction of the family by artificial methods, and that the Jews are fertile for similar reasons. The truth is that Protestants, Roman Catholics and Jews are alike infertile

or fertile according to whether they are rich or poor, prosperous or unprosperous. Giving evidence before the National Birthrate Commission, the Chief Rabbi declared that the use of contraceptives was strongly condemned among the Jews as unclean and demoralising. It may be added that from time immemorial childlessness has been looked upon among the Jews as something akin to a disgrace. Yet he pointed out that the Jewish birthrate varied greatly in different countries. "In some it is higher than in Whitechapel (it rose during the period 1886–90 owing to the immigration of poor Jews in Whitechapel from 35·7 to 38·2). For instance, in Bulgaria it is 39·6; Galicia, 38; Russia, 36; while in others it is lower than the French birthrate. For instance, 16·2 in Bavaria in the year 1913, while in 1906 in Breslau the Jewish birthrate was 15·3."[1] Roman Catholic France has about the lowest birthrate in the world for any country as a whole, while the Roman Catholic Irish become just as infertile in America as any other race. Dr. C. E. Woodruff mentions that the degree of fertility of the various races in the United States is said to be in the following order: Bohemians, Russians, Hungarians, Italians, Scotch, Scandinavian Canadians, English, Germans, French, Irish.[2] Thus, according to this list, the Irish become the least fertile of all races in America. And speaking of the Roman Catholic French-Canadians, Dr. Woodruff says: "Though the French-Canadian birthrate (49·08) is still more than double that of the English-Canadians, (23·41), the big families are becoming rare."[3] At present the French-Canadians are kept backward and ignorant by the dominance of a reactionary

[1] *The Declining Birthrate*, p. 67.
[2] *The Expansion of Races*, Woodruff, p. 178.
[3] *Ibid.*, p. 181.

priesthood; but it may be confidently predicted that with the spread of education among them their religion will in no way prevent the usual gradual decline of the birthrate.

Another factor much quoted as being largely responsible for the decline of the birthrate is the alleged spread of the practice of abortion. This also can be briefly dealt with and dismissed. The practice is familiar even to the very lowest races, and there is not the slightest trustworthy evidence that it is more prevalent now than at any other time. Miscarriage may be more frequent owing to the much greater sensitivity and more highly strung character of the modern woman; but the belief in a large increase of the practice of induced abortion appears to be based on nothing more substantial than the stories which Tom tells Dick, and which Dick repeats to Harry. Thus Mr. O. C. Beale, in his volume *Racial Decay*, mentions a tale he was told of a person in the suburbs of Melbourne who claimed to procure "twelve hundred abortions annually at a uniform fee of one pound each. She has no further trouble, but the victims trail away, all injured, some to die such lingering deaths that, if described, they would chill the reader's blood with horror." This yarn is typical of the rest, and illustrates the utter lack of critical faculty with which they are retailed. Here is a woman alleged to procure about four abortions daily, earn twelve hundred pounds a year, and deal out wholesale death and mutilation without the slightest trouble from the police, although they are continually on the watch for these things, and although we know that to be mixed up in one of these cases means professional ruin to a chemist or medical man. A whole budget of similar stories might be quoted, but they are not worth criticising. What is needed is a proper sense

of perspective. Abortion is probably most common among just those classes where, and during just those periods when, the birthrate is at its highest.

As regards the effect of increased age at marriage, evidence given before the National Birthrate Commission was to the effect that the age of the man made little difference, whereas it was found that there was a loss of about one-third of a child for each additional year of the wife's age at marriage.[1] As the age at marriage is stated to have increased only a little more than a year on the average this would account for but a small fraction of the decline, especially when we remember that in India, where child marriages are common, early child-bearing is found to result in early cessation of the child-bearing function.

The case for those who believe that the decline of the birthrate is due to artificial measures must be based upon the use of contraceptives, or means for preventing conception. This deserves more serious consideration, though, as will be presently shown, it is not necessary to discuss it at great length. It will suffice to point out that these things, to be made effective, must be used with regularity, as a single omission might result in conception, assuming that there has been no decline in natural fertility. Now, according to information gathered by the French Ministry of Finance, there were in the year 1890 2,000,000 married couples in France without children; 2,500,000 with only one child; 2,300,000 with two children; 1,500,000 with three children; and only about 1,000,000 with more than three.[2] So if we assume that the decline of the French birthrate is due to the use of contraceptives, we must assume that they are

[1] *The Declining Birthrate*, pp. 206–7.

[2] *The Times*, June 23, 1890.

used with regularity by the vast majority of married couples of child-bearing age from week to week, and this would be true of all the other leading countries of the world. This would necessitate a trade comparable in magnitude with that in some of the commoner necessaries of life, such as mustard or salt. No evidence has ever been produced of the existence of a trade of such magnitude. The fact that many shops are devoted to their sale in London or Paris proves little. Over the greater part of the country they can seldom be seen exposed for sale at all. The onus of proof rests with those who assert the existence of such a trade, but though commissions have sat in France, Australia and London, they have never yet obtained evidence of the existence of a trade comparable in magnitude with the effects it is supposed to have produced.

These commissions, indeed, failed to concentrate on the really essential question. They should have investigated the subject by asking if there has, or has not, been a vast decline in the birthrate due to natural causes, and which could not be due to the use of contraceptives on no matter how vast a scale. But their examination of this aspect of the problem was perfunctory in the extreme. To prove that prevention is practised on a considerable scale is not to prove that there has been no decline in the birthrate due to natural causes; and if there has been such a decline, it is clear that we cannot solve the problem of the birthrate until we have ascertained its extent, character and cause. And by asking ourselves this question we go straight to the essential point and avoid an immense amount of tedious and unprofitable discussion. It is possible to answer it by the use of test cases.

We will first take the results of three inquiries carried

out respectively by the National Birthrate Commission, Lady Willoughby de Broke and the Fabian Society.[1] In each case circulars were sent out to middle-class families selected very much at random, putting the direct question whether measures were taken to limit the families and asking for particulars. In the case of the first-mentioned inquiry 477 definite replies were received, and of these 287 claimed to be restricting the number of children as against 188 who claimed that their families were unlimited, or a proportion of 60·6 per cent. against 39·4. Even if these figures were worth their face value, they would not account for the facts, since, had the English race been still as fertile as, for instance, the Philippinos, we should still find enormous families among those who do not use restrictive means; but this we do not find. Some of the replies, however, contained particulars of the methods employed, and it appears that only 98 used any chemical or mechanical device, and that the remaining 105 who gave particulars merely restricted marital intercourse to those periods when conception is least likely. But there is no period when conception is not possible. It is merely a matter of the chances of conception being smaller at some periods than at others, and if the race were still as fertile as the Philippinos, conception would be certain in the course of a few weeks. Only one conception every twelve months or so is necessary to produce the largest families. Now, if we assume that the same proportion prevails among those who gave no particulars, we find that of the 477 who gave definite replies only about 140, or less than a third, claim to be taking any really effective measures to limit their families, a proportion utterly inadequate to account for the general decline.

[1] *The Declining Birthrate*, p. 21 *et. seq.*

The small inquiry conducted by Lady Willoughby de Broke yielded very similar results. Some 94 definite replies were received, and of these 75 claimed that the families were limited as against 19 which asserted that no limitation was practised. But 70 replies gave particulars, and it seems that in only 33 cases were artificial methods used against 37 in which the only method was voluntary restraint. Thus we find that only a little more than a third of the definite replies claimed that any really effective methods of limitation were adopted.

In the case of the Fabian Society's inquiry (conducted by Mr. Sidney Webb), of 316 marriages 242 were reported to be limited as against 74 unlimited. In this case no particulars of the methods used were given, but if we assume the same proportion to prevail in this case as in the others between those who took definite measures to limit the family and those who merely confined intercourse to the supposed "safe" periods—quite a reasonable assumption—we again find that only about one-third were taking any really effective contraceptive measures.

But the most striking fact has yet to be mentioned. In the case of the first inquiry the number of children per marriage (excluding childless marriages) was actually greater among those families claiming to be limited than among those where no contraceptive measures were taken. The average number of children per family in the one case was 2·4, in the other 1·6. Lady Willoughby de Broke's inquiry showed that the average "limited" family was $3\frac{1}{8}$, whereas in the "unlimited" families the average was only $2\frac{1}{2}$. The Fabian inquiry showed that the "limited" family numbered on the average 2·7 and the "unlimited" family 2·88; but the average duration of the former was only fourteen years against eighteen years for the latter.

These inquiries were conducted mainly among the middle-classes, and that of the Fabian Society was confined to its own members, the subjects ranging from skilled artisans to professional men, but "(with few exceptions) the tiny fraction of the population who have incomes from investments exceeding £1,000 a year" were excluded. Thus the individuals selected by the Fabian Society were almost exclusively people of limited means, active intelligence and considerable ambition. Had it been desired to select that section of the earth's population which, above all others, was most likely to be using contraceptives, no better choice could have been made. Yet, in spite of this, only about one-third appear to have been taking real contraceptive measures; while in the case of two inquiries out of three the number of children per family was actually smaller in those families which were unlimited than in those where it was claimed that contraceptive measures were taken.

In face of these facts the National Birthrate Commission brought in a verdict that there is no evidence of a decline in fertility due to natural causes, and met the fact that the "limited" families were larger than the "unlimited" by declaring that "this divergence could no doubt be explained in many ways." No attempt was made, however, to give even a single explanation. To any one with an unprejudiced mind it must be obvious that these facts, if they can be regarded as trustworthy, provide decisive proof that the use of contraceptives is not on a scale sufficient to account for the decline of the birthrate, and that there has been a decline of natural fertility sufficient to account for the whole phenomenon. The verdict of the National Birthrate Commission is one more striking example of the hypnotic effect of preconceived ideas.

Quite apart from the above facts, the commission had before it an abundance of testimony that there has been a decline of fertility due to natural causes. Dr. Mary Scharlieb [1] testified that as the result of her inquiries among women she finds that those who do not interfere with nature do not now have such enormous families. Out of 160 cases of childless women which came under her notice in only seven instances was this due to deliberate prevention. A considerable number of leading scientific and medical men and women testified to the reality of the decline of fertility apart from the use of contraceptives.[2]

An abundance of evidence can readily be found by those who will consent to look at it and do not allow themselves to be hypnotised by preconceived opinions. On this point some interesting facts will presently be given, but first it will be well to point out that the best test of whether there has or has not been a decline of natural fertility is to be found in the proportion of completely sterile marriages among the very rich, and among those people who we may suppose would have been keen to have at least one or two children. It is the testimony of every intelligent observer of human nature that the desire for one or two children is almost universal among those people who have adequate means to support them. Therefore, if there has been no decrease of natural fertility, we cannot expect to find any great increase of completely infertile marriages among people of means and intelligence; whereas if there has been a great decrease of fertility due to natural causes, we may expect to find a proportionate increase of completely childless families

[1] *The Declining Birthrate.*

[2] Including Dr. John Brownlee, Prof. Leonard Hill, Dr. Halford Ross, Dr. Chalmers and others.

among the well-to-do. And these childless marriages among the wealthy provide the best test, because here the use of contraceptives as an explanation may be ruled out almost with certainty; whereas where there are children, even though only a few, it is possible to argue that there are as many as are desired; while in the case of childless people of limited means it is possible to argue that they do not feel that they can afford to support children.

We can now examine a few interesting test cases. Darwin mentions that 19 per cent. of the English nobility are childless, "which is more than three times the average for the rest of the nation."[1] As the English nobility have titles and usually considerable wealth to transmit to their heirs, and as they generally marry for the express purpose of obtaining heirs, this fact requires some other explanation than the use of contraceptives. The late Sir Francis Galton suggested that childlessness among the peerage was frequently due to marriages between the peers and heiresses, who are often the only children of their parents and therefore of infertile stock. This may sometimes be a contributory cause, but as an explanation it is utterly inadequate. Only a fraction of the peers marry heiresses, and of these only a small proportion will be of infertile stock. Moreover, the argument is negatived by Galton's own principle of Regression to Mediocrity. If parents are so infertile as to have only a single child during a normal length of married life, they will, in respect of fertility, be abnormal variations—variations, that is, a long way from the mean or average of the race. According to the law of Regression to Mediocrity an abnormal variation usually

[1] *Dictionary of Statistics*, Mulhall. I believe that the percentage is now considerably larger.

reverts back towards the mean or average of the race in the next generation. As fertility is subject to the laws of variation, the only child of infertile parents should be less infertile, on the average, than the parents were. There seems to be no escape from the conclusion that the large proportion of sterile marriages among the English nobility is due to the circumstances under which they live.

In his work, *The Family and the Nation*, Dr. Whetham has given figures showing the degree of fertility among "men of specialised ability occupying permanent posts in the University of Cambridge." It appears that in 1909 there were forty childless couples who had been married for periods of five years or longer, while seventy married couples whose youngest child was over ten years of age had produced 199 children. Although the way in which the figures are given obscures the proportion, it is evident that there is a remarkably large number of completely sterile couples. Apparently it is considerably greater than that shown by the peerage. But there can be no question of heiresses in this case. Shall we then assume that they have used contraceptives from the very marriage eve? Dr. Whetham admits that "the large proportion of childless couples may indicate that men and women of academic distinction are often not fertile and inclined to late marriages, while the average number (2·84) of children to a marriage which produces any offspring is closely concordant with that in other sections of the educated class, and is probably determined by the same causes." So, while Dr. Whetham is disposed to acquit the completely sterile couples of being so unnaturally selfish as to take the most troublesome precautions from the very marriage eve to avoid having a single child, yet he assumes that those who have a few children must be limiting their families. But

we shall find as we proceed ample evidence that intellectual activity is inimical to fertility, and if this result is so marked among the completely sterile it should be capable of reducing the average fertility of the rest. Why is it necessary to appeal to natural infertility in one case and not in the other?

What are the implications if, as Dr. Whetham admits, the sterility of the childless marriages is due to natural causes? It is impossible to assume that the environment has picked out a certain number of couples and annihilated their fertility, while leaving the fertility of the remainder unaffected. When wild animals are confined it is found that the very fertile types are rendered only moderately fertile; that the moderately fertile types are rendered only slightly fertile; and that the slightly fertile types, such as parrots, are rendered completely sterile. So, then, with the wives of Cambridge professors and others. We should expect that conditions which render completely sterile those whose natural fertility is very slight would render the moderately fertile individuals only slightly fertile, and the very fertile individuals only moderately fertile. The low average fertility, therefore, is the logical consequence of conditions which render so large a proportion completely sterile.

Those classes the members of which combine a comfortable income with a considerable degree of intellectual activity have invariably a very small average family, and a very large proportion of completely childless couples. Thus the average number of children among the English intellectuals is about 1·5, and the proportion of childless marriages among any selected body of them will usually work out at from 25 to 33 per cent. Taking a list of twenty-eight of the leading members of the Eugenics

Society, I found that the average size of their families was 2·33, and that 25 per cent. of the marriages were childless. The Eugenics Society is composed of able people who believe that it is desirable to secure the largest possible proportion of children from the ablest sections of the community, and that the present position in which the least capable are reproducing most rapidly is likely to be disastrous to the efficiency of the race in the long run. It is not at all likely that they would publicly expound such beliefs and yet take measures to limit their own families, seeing that they are themselves among the abler sections of the community. Here again the number of completely sterile marriages provides the best test, and by far the most probable explanation is that the vast proportion of such marriages among them is due to the same causes which have produced a similar result among the staff of Cambridge University. The proportion is greater than among the nobility, and illustrates the fact that intellectual activity seems to be more potent in reducing fertility than social position. It may be added that the families do not consist almost exclusively of one or two children as we should expect on the contraceptive theory, but of sterile marriages, with ones, twos, threes, fours and fives, scattered in just the random fashion we should expect from a natural law.

A still more instructive case is that of the members of the National Birthrate Commission. Here is a body of people who sincerely believe that unless some means are found of grappling successfully with the birthrate problem we run the gravest risk of ultimate disaster. So strongly do they feel on this point that they give their services gratis for a considerable time in order to investigate the problem. Yet I find that the average number of children per family among them is only 1·75,

and that sixteen out of the forty-one whom I was able to look up are childless![1]

Of course, a good deal of cheap cynicism might be indulged in over the fact that over one-third of them are without children, and that they brought in a verdict that there is no evidence of a decline of fertility due to natural causes; but my own explanation of the case is that it is just because they were conscious, in each individual case, that their childlessness was the result of natural causes that they consented to sit on the commission. In truth, the cynical attitude which many people mistake for a knowledge of human nature really represents a profound ignorance of human nature. Had infertility in this case been due to anything but natural causes, they would have avoided that Commission. A curiously similar instance is provided by the case of the Emperor Augustus. He only obtained one child from a sequence of three wives himself, yet all his measures to combat the declining birthrate of Rome were based on the assumption that there was no decline of natural fertility. It may be added that a footnote to Gibbon mentions that the marriages of the Emperors were usually infertile.

Statistics show that there are as many as 25 per cent. of completely infertile marriages among sections of the native-born population of the United States, and this appears to be the rule among those people who combine considerable means with considerable intellectual activity. Why intellectual activity and infertility should go together will be explained later, but now we may inquire whether these childless people desire children or not. The development of the birthrate problem has seen the invention

[1] According to the figures given in *Who's Who*, not necessarily accurate to a decimal point, but probably not far out.

of a strange being who may be best described as the "demographic woman." She bears to this problem much the same relation that the "economic man" bore to the science of political economy during the first half of last century. That is to say, she resembles nothing actually living on the earth, but is a weird, phantom creature invented in the attempt to justify untenable theories. By some strange process she has lost every trace of her natural instinct. Far from having a natural desire for children, she is prepared to take the most troublesome precautions from the very marriage eve to avoid having a single child, yet, strange to say, is said to lavish more affection on a pet dog or cat than would suffice for a houseful of babies. Many people have heard of her, but very few people have met her. She is vaguely referred to as the "Society woman," though whose society she frequents it is difficult to say. For those who talk so knowingly about her would be indignant if it were suggested that she is to be found among their own wives, their own mothers, their own sisters, or even among their relatives and friends. The "demographic woman" is invariably someone else's wife, sister, or friend.

Of course, this strange creature is mainly the product of undisciplined imaginations. She is the result of seeing everything in false perspective and raising the exception to the position of the rule. The most unnatural specimens of femininity to be discovered are seized upon and represented as typical of the whole. A taste for short skirts or transparent stockings is regarded as a sure sign of degeneration; while the natural tendency of childless women to lavish affection upon cats and dogs is represented as clear proof that they are devoid of all natural instincts. The worst possible construction is placed upon everything they say or do. It would be more

charitable to infer that their peculiar affection for cats and dogs is due to the absence of more natural objects of affection through causes beyond their control.

Surely it is time to call a truce to these extravagant and rather libellous assumptions put forward in the effort to justify untenable beliefs. In face of the enormous proportion of completely childless marriages among the intellectual classes generally, the wives of the leading members of the Eugenics Society, the wives of members of the staff of Cambridge University, and other sections of the community, it is not unreasonable to ask people to reflect upon the implications of these assumptions. At any rate, before accepting the view that there has been a wholesale degeneration of the natural instincts of the wives of the ablest members of the community we are justified in asking for proof, and thus far not a scrap of trustworthy evidence in support has been supplied.

All the evidence points to the conclusion that these childless couples keenly desire children. Nearly every doctor or other authority competent to express an opinion is emphatic in his testimony that the overwhelming majority of married women want one or two children, and anyone who will note the hungry looks of childless women in the presence of children will easily confirm this opinion. The following passage, written by an acute observer of human nature during a visit to the United States, and descriptive of the attitude of the American people towards children, is typical of the impression made upon those who do not happen to be trying to justify preconceived ideas at the moment: "You may see that couple later—or a couple that might have been them—in a suburban house—a real home for the time being—with a colourable imitation of a garden all about it, and 'the finest suburban railway service in the world'

just round the corner: the whole being a home and environment for the rearing of children. I have sat at dinner in such houses, and the talk was of nothing but children; and anybody who possessed any children, or any reliable knowledge of the ways of children, was sure of a respectful hearing and warm interest. If one said: 'By the way, I think I may have a photograph of the kid in my pocket,' every eye would reply immediately, 'Out with it man—or woman!—and don't pretend you don't always carry the photograph with you in order to show it off!' In such a house it is proved that children are unmatched as a subject of conversation. And the conversation is rendered more thrilling by the sense of partially tamed children—children fully aware of their supremacy—prowling to and fro unseen in muddy boots and torn pinafores, and speculating in their realistic way on the mysteriousness of adults. 'We are keen on children here,' says the youngish father frankly."[1] Such a passage needs no comment beyond pointing out that in these very circles the number of childless marriages may be anything up to 25 per cent.

One striking confirmation of the view that childless women usually desire children is to be found in the growth of a large demand for children for adoption in this country. The supplying of this demand—which comes from all classes, ranging from miners to millionaires—has been organised by the National Children Adoption Association, and nearly fifteen hundred applications for children for adoption have been received. Curiously enough, these are not all from childless couples, but frequently come from people who have one child and want another. Perhaps they have a boy and want a girl, or vice versa. Girls, it seems, are in much greater demand than boys. This

[1] Arnold Bennett, *Harper's Magazine*, November, 1912.

demand for children for adoption is symptomatic of a much larger desire for children, since for every couple who are prepared to adopt the children of strangers there will be hundreds of couples who keenly desire children of their own, but hesitate to adopt children of doubtful heredity.

An account of a similar and much larger demand for children for adoption in the United States appeared in the *Cosmopolitan Magazine* for September 1910. It was even stated that the demand exceeded the supply; but as I have not been able to confirm these statements, I do not insist upon them. Yet it stands on historical record that there was a decline in the birthrate of Ancient Rome and Greece similar to that which we are witnessing to-day, and the practice of adopting children sprang up among the childless then even as it is doing now. Then also the current explanation was that the people were deliberately evading child-bearing, and that, out of "pure cussedness" and wrongheadedness apparently, they preferred to adopt the children of strangers rather than have children of their own. Are a few thousand more years to pass before the world will consent to make the common-sense recognition of the fact that these things are governed by natural laws not yet under our control?

The statesmen of Ancient Rome were not blind to the dangers which threatened their country as the result of the declining birthrate. The Emperor Augustus chased the red herring of "race suicide" to far greater lengths than the statesmen of to-day have done, and offered the most lavish privileges to the parents of large families. But it was all in vain. The matter was not within the parents' control. In spite of all efforts to check the decline, the ancient Roman race practically died out, and was replaced by a miscellaneous collection of aliens. The

same fate overtook the Ancient Greeks, and the surface of the earth is covered with the ruins of ancient civilisations which rose to power, became great, and then were stricken with a mysterious decline. The same fate may overtake our civilisation of to-day unless our statesmen rouse themselves, investigate the problem along scientific lines, and grapple with the question as a true statesman would.

CHAPTER II

THE PRINCIPLE DEDUCED

In considering the problem of animal fertility the subject may be divided into two parts :—

(1) The variation of the inherited *potential* degree of fertility as between species and species ; and

(2) The variation of the *actual* degree of fertility of a given species under the direct influence of the environment.

The second of these is the really important question. The first is only important from our present point of view from the fact that its solution may lead to the solution of the second. If we can obtain a generalisation accurately defining the facts of the first problem, we may be able to deduce therefrom the solution of the second.

The theory of evolution assumes the development of the higher forms of life, through an ascending grade of types, from the most primitive life-cells. A rate of reproduction suitable for the lower types will not be suitable for the higher. As the most primitive life-cells have a rate of reproduction which makes an individual the ancestor of billions in the course of a few days, it follows that from these up to man and the still slower-breeding elephant the rate of reproduction must be graduated down according to definite principles. Our task is to express these principles in a single generalisation.

The necessary condition of the continued existence of any species is that its reproductive capacity should be

sufficient to maintain its numbers in the environment under which it lives. On the other hand, it is a necessary condition of progressive evolution that the reproductive capacity should diminish as the survival-capacity of the organism increases. In other words, that the birthrate should diminish as the deathrate diminishes. For, except under exceptional circumstances, where there is ample opportunity for expansion, it is obviously impossible to have a high birthrate and a low deathrate. If the birthrate does not diminish, then the deathrate cannot, in the long run, diminish either. On the other hand, where the deathrate is high, the birthrate must be high also, or the species will become extinct. "The condor[1] lays a couple of eggs and the ostrich a score, and yet in the same country the condor may be the more numerous of the two; the fulmar petrel lays but one egg, yet it is believed to be the most numerous bird in the world. One fly deposits hundreds of eggs, and another, like the Hippobosca, a single one; but this difference does not determine how many of the two species can be supported in a district. A large number of eggs is of some importance to those species which depend on a fluctuating amount of food, for it allows them to rapidly increase in number. But the real importance of a large number of eggs or seeds is to make up for much destruction at some period of life, and this period in the great majority of cases is an early one. If an animal can in any way protect its own eggs or young, a small number may be produced, and yet the average stock be fully kept up; but if many eggs or young are destroyed, many must be produced, or the species become extinct."[2]

In short, it is a necessary condition of the success of the whole evolutionary scheme that the birthrate and

[1] See p. 170. [2] *Origin of Species*, Darwin, chap. iii.

the deathrate should, in the long run, compensate each other. Therefore we may express the facts in the following generalisation :—

The inherited potential degree of fertility of a species in comparison with that of another species will bear an inverse proportion to its capacity for survival under the environment to which it is adapted.

The validity of this generalisation is almost self-evident. The fact that a species survives in undiminished numbers is conclusive evidence that its rate of reproduction bears a suitable proportion to its capacity for survival under that environment. To illustrate this, we will take the case of the mouse in comparison with that of the brown rat. Although the rat is many times larger than the mouse, their rates of reproduction are approximately similar. The mouse, however, is tolerated where the rat is fiercely persecuted. The former, owing to its smaller size, can find its way into places inaccessible to the latter, is less conspicuous, and can live upon scraps of food which would be utterly insufficient for the rat. As a consequence, the brown rat, in spite of its greater size, strength and cunning, needs as high a rate of reproduction as the mouse in order to maintain its numbers. Again, the water-rat, although somewhat smaller and weaker than the brown rat, has a much lower rate of reproduction. That this low rate of reproduction is sufficient is shown by its survival in undiminished numbers. It is subject to little persecution, has great powers of evasion owing to its semi-aquatic habits, and lives on vegetable food which it can find in abundance all the year round.

Thus we see that each species has a normal rate of reproduction approximately suitable to the conditions of its environment. The potential degree of fertility will

be fixed by the general principles of variation and adaptation which govern evolution as a whole. Into the nature of these principles it is no part of our purpose to enter here. Suffice to say, that as the factors which make for survival develop fertility must diminish. The chief of these factors will be cerebral development, size, weapons of defence and organs of locomotion. All of these will be important, but, as a factor making for survival, cerebral development overshadows all the rest. Man, who is deficient in all the other factors, is nevertheless enabled to increase rapidly in numbers with a rate of reproduction lower than that of any animal save the elephant. The paramount importance of this factor should be borne in mind in considering the next part of our subject.

We now come to the really important part of the problem. The question which we have to answer is: What law governs the variation of the degree of fertility in response to the direct action of the environment? We have seen that it is a necessary condition of the success of the evolutionary scheme that the variation of the inherited potential degree of fertility between species and species must bear an inverse proportion to their capacity for survival. But the *actual* degree of fertility is decided by the direct action of the environment, and if this generalisation is to hold good for the larger problem, it must also hold good for the net result of the variation of the degree of fertility under the direct action of the environment. And this may be effected in one of two ways: the birthrate and deathrate may rise and fall together; or periods of relative barrenness and great mortality may alternate with periods of great fertility, as we see among the lower organisms.

To produce the first result it is necessary that the same combination of causes which results in a high deathrate

should produce also a high birthrate, and that the same combination of causes which produces a low deathrate should produce also a low birthrate. As the purpose of this work is to elucidate the law which governs the degree of fertility in human society, and as in human society both births and deaths are fairly regular from season to season, it follows that this is the method with which we are most concerned. Therefore we will deal with this method first, leaving the alternative method for later discussion.

We may express the necessary condition of survival and of progressive evolution in the following generalisation :—

The net result of the variations of the degree of fertility under the direct action of the environment will bear an inverse proportion to the variations of the capacity for survival.

And in order that birthrate and deathrate may rise and fall together it is necessary that—

The variation of the degree of animal fertility in response to the direct action of the environment shall bear an inverse proportion to the variation of the survival-capacity under that environment.

This generalisation will need an important qualification which can be considered later. But we need something more definite than this. We need to know the factor in the organism which controls the variation. Can this be deduced from the above generalisation ?

It is clear that such a phenomenon as the variation of fertility must bear a definite relation to some factor within the organism. It cannot be wholly " in the air." Our task, then, is to find out to what factor or factors it bears this relation and what the relation is. Clearly, if the degree of fertility is to bear an inverse proportion

to the capacity for survival, it must bear a similar relation to the factors which make for survival. As these factors wax, fertility must wane, and vice versa. What, then, are the factors which affect survival-capacity and which vary with the environment?

There are two parties to this question: the organism and the environment. There are factors in the environment which act on the organism and make for survival or elimination; and there are factors within the organism which react to the environmental factors. The factors in the environment which act on the organism may be broadly stated as follows:—

Food: both quantity and quality.
Climate: hot or cold; moist or dry.
All those varied factors which make for greater or lesser mental and physical activity.

If we can find within the organism a factor which reacts to all these environmental factors, and is at the same time the factor above all others which makes for survival, that factor we may be sure is the one we seek. Where shall we look for it?

We have seen that the development of the nervous system is the factor above all others which makes for survival in the struggle between species. So we may first direct our search there. The mass of the nervous system, though it may be largely developed by the action of the environment, will bear a fairly constant ratio to the rest of the organism throughout life after maturity is reached. Is there any factor within or developed by the nervous system capable of reacting to all the varied factors of the environment—a factor which will vary with the environmental factors, forming an approximately accurate measure of the survival-value of the

whole? There is such a factor. It is known as nervous energy.

If our food varies, whether in quantity or quality, it will have an immediate effect on the sum of our nervous energy.

If the climate varies, hotter or colder, moister or dryer, it will have an immediate effect on the sum of our nervous energy.

And any factor in the environment, no matter what, which makes for greater or lesser mental or physical exertion will have an immediate effect on the sum of our nervous energy.

Nervous energy, moreover, is the factor above all others which makes for survival.

As this factor answers all the necessities of the case, and as it appears to be the only factor within the animal organism which does answer all these necessities, it follows that—

The variation of the degree of animal fertility in response to the direct action of the environment will bear an inverse proportion to the development of nervous energy.

We shall see later that in human society birthrate and deathrate rise and fall together with remarkable regularity. The most obvious inference which we can draw from this is that the same combination of causes that produces a high deathrate produces also a high birthrate, and that the same combination of causes that produces a low deathrate produces also a low birthrate. In order that this result may be, the factors which make for death or survival must be co-ordinated and their survival-value measured with approximate accuracy. The great co-ordinating factor of the animal organism is the nervous system, and nervous energy is its active agent.

CHAPTER III

THE PRINCIPLE AS MANIFESTED IN THE VEGETABLE KINGDOM

As both the animal and vegetable kingdoms are, without doubt, governed by the same biological laws, our principle should apply to the latter as well as to the former, though clearly not in its present form, as plants possess, so far as is known, no nervous energy. But the function of the nervous system in animals appears to be fulfilled in plants by protoplasmic extensions connecting cell with cell, and, as the functions of the various parts of a plant are mutually co-ordinated, we must assume the presence of some co-ordinating factor. Otherwise we should have an effect without a cause. If this factor should at any time be located, it will take the place in our formula occupied by nervous energy. In the meantime we may substitute the term "vitality" as expressing that general vigour of growth which springs from a favourable combination of circumstances.

The variation of the degree of vegetable fertility in response to the direct action of the environment will bear an inverse proportion to the development of vitality.

This term will be sufficiently precise for our purpose, but the principle will need an important qualification. It is clear that in an environment that is absolutely barren and devoid of nourishment no seed will be produced. Seed will only be produced where there is a supply of nutrition, as Nature does not make bricks

without straw. We have seen that the maximum degree of fertility of which the plant is capable will be decided by inheritance. Clearly, then, from absolute barrenness the degree of fertility will develop in a direct ratio with the supply of nutriment until the inherited potential maximum is produced. It is then, and only then, that the above rule will become operative. The full principle, then, may be set forth thus :—

The variation of the degree of vegetable fertility in response to the direct action of the environment will be directly proportional to the development of vitality (or protoplasmic energy) until the optimum point for fertility is reached; it will thenceforward be inversely proportional to the development of vitality.

Thus this generalisation really represents the application of the principle of the vital optimum to the question of fertility. For the organism there is always a *best* point, degree, or quantity of every factor in the environment. There is always a best temperature for the organism, a best degree of moisture, a best quantity of any nutritive factor. This *best* point or degree is not always the same, even for the same organism, but is subject to variation. Yet, no matter what may be the optimum point at any given time, any variation of conditions away from that optimum is to that extent harmful to the organism.

Obviously there must also be an optimum or best point for fertility for any factor in the environment, and the arrangement set forth in the generalisation given above seems to be the only one possible. The organism must be able to adjust its rate of increase, not only to conditions to which it is well adapted, but to conditions of extreme richness and extreme poverty. As the maximum potential degree of fertility will be decided by

inheritance and must be adjusted to a certain ideal combination of conditions, it follows that any variation from this ideal in any direction must result in lessened fertility.

The potential degree of fertility being inherited and subject to variation, it follows that those domesticated plants which are cultivated for a heavy yield of seed will be much more fertile than similar wild types. The heavy yield of seed under favourable conditions will be produced by selection.

Darwin, it is true, expresses a somewhat different opinion: "With those plants which are valued for their seed, the direct selection of the more fertile individuals has probably much increased their fertility; and in all cases this may have occurred indirectly, from the better chance of some of the numerous offspring of the more fertile individuals having been preserved. But . . . with plants like carrots, cabbages and asparagus, which are not valued for their prolificacy, selection can have played only a subordinate part, and their increased fertility must be attributed to the more favourable conditions of life under which they have long existed." [1]

This last sentence is an example of the explanation which explains nothing. Why should a long continuance of favourable conditions have produced a high degree of reproductive fertility in some plants, whilst, as we shall presently see, it has produced in others almost complete sterility? It is notorious that all those plants which are valued for their seed crop, such as corn, peas, beans, etc., have reached their present high degree of fertility through long and careful selection. But what of those plants which are not valued for their seed? These plants may be divided into two classes: those which

[1] *Variation of Animals and Plants under Domestication*, chap. xviii.

are propagated by seed, and those which are propagated asexually by means of cuttings, buds, tubers, etc. When a nurseryman raises a crop of cabbages for seed it is obviously to his advantage that they should give as large a yield of seed as possible. In such cases, unlike apples, pears or oranges, the heavy yield of seed in no way interferes with the edible qualities of the vegetable, and if he can obtain as much seed as he requires from a hundred cabbages instead of having to raise a thousand it will make a considerable difference to his profits. As a consequence, all plants which are propagated by seed will be cultivated for a heavy yield of seed. On the other hand, those plants in which a heavy yield of seed interferes with their edible qualities are usually propagated asexually, and the general rule is that asexually propagated plants are selected for seedlessness.

In examining the facts, then, we may expect from our principle certain broad results. As wild plants are usually developed under conditions of severe competition, they will be adapted to produce their maximum degree of fertility under relatively unfavourable conditions. Consequently we may expect, as a general rule, that their fertility will decline when they are transplanted to the highly favourable conditions of cultivated gardens.

We may expect that plants which are cultivated for a heavy yield of seed, or are propagated by seed, will increase in fertility with increased favourability of conditions up to a certain point (the optimum point for fertility); but that when a certain point of favourability has been passed fertility will begin to decline.

We may expect that asexually propagated plants will show a steady decline of fertility (i.e. production of fertile seed) in proportion as they are highly cultivated.

These anticipations are borne out by the facts with

remarkable uniformity. It may be noted here that the theory is a theory of fertilisation, and, for reasons to be made clear later, has no application to asexual reproduction.

Darwin, in his *Variation of Animals and Plants under Domestication*, brought together a large body of evidence bearing on this question. As this body of evidence represents the observations of many years, and as Darwin was the most indefatigable and reliable of observers, we may fairly take it as accurately representative of the facts as a whole. The following extracts will show that the general rules deduced from the principle are fully borne out by the facts.

"It is notorious that many plants in our gardens and hot-houses, though preserved in the most perfect health, rarely or never produce seed. I do not allude to plants which run to leaves, from being kept too damp, or too warm, or too much manured; for these do not flower, and the case may be wholly different. Nor do I allude to fruit not ripening for want of heat, or rotting from too much moisture. But many exotic plants, with their ovules and pollen appearing perfectly sound, will not set any seed. The sterility in many cases, as I know from my own observation, is simply due to the absence of the proper insects for carrying the pollen to the stigma. But after excluding the several cases just specified, there are many plants in which the reproductive system has been seriously affected by the altered conditions of life to which they have been subjected."[1]

Darwin then proceeds to give many instances showing the sterility of wild plants when transplanted to cultivated gardens, together with exceptions to this rule. He gives no instance of a plant whose fertility is directly increased

[1] *Variation of Animals and Plants under Domestication*, chap. xviii.

by cultivation without the intervention of selection. We are justified in inferring, although Darwin does not make this point perfectly clear, that the wild plants which seed freely in cultivated soil are, as a rule, less fertile at first than in a wild state.

He goes on to say: "Too much manure renders some kinds utterly sterile, as I have myself observed. The tendency to sterility from this cause runs in families; thus, according to Gartner, it is hardly possible to give too much manure to most Graminæ, Cruciferæ and Leguminosæ, whilst succulent and bulbous-rooted plants are easily affected. Extreme poverty of soil is less apt to induce sterility, but dwarfed plants of *Trifolium minus* and *repens* grown on a lawn often mown and never manured were found by me not to produce any seed." [1]

Observe that the plants mentioned as being difficult to reduce in their fertility by heavy manuring are propagated by seed, or cultivated for a heavy yield of seed in a rich soil. We must expect considerable variation between different varieties in their response to a given combination of conditions, as they will represent different degrees of adaptation.

"Many of our most valuable fruits, although consisting in a homological sense of widely different organs, are either quite sterile, or produce extremely few seeds. This is notoriously the case with our best pears, grapes and figs, with the pineapple, banana, breadfruit, pomegranate, azerole, date-palms and some members of the orange tribe. Poorer varieties of these same fruits either habitually or occasionally yield seed. Most horticulturists look at the great size and anomalous development of the fruit as the cause and sterility as the result, but the

[1] *Variation of Animals and Plants under Domestication*, chap. xviii.

opposite view, as we shall presently see, is the more probable." [1]

It is, no doubt, probable that sterility may in some measure react on the size of the fruit. But it is a necessary deduction from the principles of organic evolution that the degree of fertility shall be decided by the condition of the organism as a whole, and not vice versa. To allow the environment to act directly on the reproductive system, and through the resulting effects modify the rest of the organism, would, from an evolutionary point of view, be absurdly futile. This would make a species the mere appendage of its reproductory system instead of making the reproductory system serve the purpose of maintaining the species. It is no reply to this to point to the effects of castration on the rest of the organism. The effects of castration are not the effects of sterility resulting from the action of the environment, but are the results of the loss of certain hormones caused by the extirpation of the glands which produce them. Observe that the fruits which are notorious for sterility are invariably propagated asexually, and consequently are not selected for the production of fertile seed, but usually for seedlessness. As a result the principle has full play, and these fruits become more infertile in proportion as they are highly cultivated.

With plants which are cultivated for a heavy yield of seed the result is directly opposite. "With respect to plants, no one would expect wheat to tiller more, and each ear produce more grain, in poor than in rich soil, or to get in poor soil a heavy crop of peas or beans. Seeds vary so much in number that it is difficult to estimate them, but on comparing beds of carrots in a nursery garden with wild plants, the former seemed to produce

[1] *Variation of Animals and Plants under Domestication*, chap. xviii.

about twice as much seed. Cultivated cabbages yielded thrice as many pods by measure as wild cabbages from the rocks of South Wales. The excess of berries produced by the cultivated asparagus in comparison with the wild plants is enormous." [1]

Though these plants have been cultivated for a heavy yield of seed under favourable conditions, yet, if these favourable conditions are carried to excess, sterility results.

"Plants which from any cause grow too luxuriantly and produce leaves, stems, runners, suckers, tubers, bulbs, etc., in excess, sometimes do not flower, or if they flower do not yield seed. To make European vegetables under the hot climate of India yield seed, it is necessary to check their growth, and when one-third grown, they are taken up and their stems and tap-roots cut or mutilated." [2]

This mutilation being obviously to check nutrition is a conclusive refutation of Darwin's own contention that the luxuriant growth of certain fruits is more probably due to sterility than that sterility is due to luxuriant growth.

The operation of the principle as a whole is admirably illustrated by the following: "With the varieties of many plants, the adaptation to climate is very close. Thus it has been proved by repeated trials 'that few if any of the English varieties of wheat are suitable for Scotland,' but the failure in this case is at first only in the quantity, though ultimately in the quality of the grain produced. The Rev. M. J. Berkely sowed wheat seed from India, and got 'the most meagre ears' on land which certainly have yielded a good crop from English wheat. In these cases varieties have been carried from

[1] *Variation of Animals and Plants under Domestication*, chap. xviii.
[2] *Ibid.*

a warmer to a cooler climate; in the reverse case, as 'when wheat was imported directly from France into the West Indian Islands, it produced either wholly barren spikes or furnished with one or two miserable seeds, while West Indian seed by its side yielded an enormous harvest.'" [1]

Nothing could be more obvious than the application of the principle to these facts. As the optimum point for fertility will be a certain ideal combination of conditions, therefore English, Scotch, French and Indian seed will each be adapted by selection to a different combination of conditions. It follows that any material change in these conditions in either direction can only result in lessened fertility. The English farmer looks for plenty of sun and rain at the right seasons, together with a rich soil, to produce a heavy crop of wheat. Yet European seed transplanted to the West Indies, where all these things are present in excessive abundance, is rendered almost completely sterile. These same varieties could be adapted by careful selection to any reasonable combination of conditions. Yet they would still remain subject to the general principle which governs the variation of the degree of fertility in response to the direct action of the environment—the law of the optimum point of fertility.

Herbert Spencer, advocating the view that the degree of fertility is directly proportional to the surplus of nutrition over and above the cost of individuation, says of fruit-trees: "Were it otherwise, dunging the roots of a fruit-tree would be in all cases impolitic, instead of being impolitic only when the growth of sexless axes is still luxuriant. Were it otherwise, a tree which has borne a heavy crop should, by the consequent depletion,

[1] *Variation of Animals and Plants under Domestication*, chap. xxiv.

be led to bear a still heavier crop next year; whereas it is apt to be wholly or partially barren next year—has to recover a state of tolerably high nutrition before its sexual genesis again becomes large." [1]

Spencer does not make it clear why, on his theory, it should be impolitic to dung the roots of a fruit-tree while the growth of sexless axes is still luxuriant. On the theory sketched out here, it is because the growth of sexless axes is a sign that the degree of nutrition has passed the point which is adapted to produce the maximum degree of sexual fertility. As Spencer points out, the change from the production of seed-bearing fruit to the production of sexless axes is a change from sexual to asexual genesis. This latter can be dealt with later, but it may be noted that Spencer's theory makes no provision for the fact, clearly shown in the above extract, that the conditions most favourable to asexual genesis are inimical to the sexual process.

In the large body of evidence brought together by Darwin bearing on this question, not a single fact is mentioned inconsistent with the theory. A number of facts are given which at first sight appear capricious or of ambiguous interpretation. Thus a plant is mentioned which "is a native of the moderately warm banks of the Plata, seeds freely in the hot, dry country near Lima, and in Yorkshire resists the severest frosts, and I have seen seed gathered from pods which had been covered with snow during three weeks." [2] But this merely points to a wide range of adaptation due to some peculiarity of constitutional organisation, such as that which enables some men to endure vast changes of temperature and suffer little inconvenience, while others are

[1] *Principles of Biology*, vol. ii, chap. ix.

[2] *Variation of Animals and Plants under Domestication*, chap. xviii.

sensitive to the slightest change. If the organism can remain unaffected by the change, there seems no reason why its reproductive system should be affected.

On the other hand, Darwin mentions that a very slight change, such as a little more or less water at some period of growth, will sometimes determine fertility or sterility. This, again, is in no way inconsistent with the principle. A very slight cause may have a very powerful effect on the vitality of the organism as a whole, and thus affect the degree of fertility. We shall see later good reason to believe that a little more or less moisture in the atmosphere may, by its direct effect on the individual, and by its indirect effects through its influence on social habits, powerfully affect the fertility of the human race.

These few remarks on the influence of the environment on the degree of vegetable fertility are little more than a digression from our main purpose. But they have served to complete the statement of the principle and to show that it applies to vegetable as well as to animal fertility; while that the same general law runs through the whole scheme of organic reproduction will be shown as we proceed. In considering the facts it should be borne in mind that the degree of sexual fertility must be judged by the number of fertile seeds, not by the amount of fruit. It should also be borne in mind that we cannot expect from a general principle a detailed explanation of particular cases, or an apparent conformity in every case. Within the scope of every general principle there are at work numbers of minor and counteracting principles. These often obscure the action of the main principle and produce results at first sight contradictory or inconsistent.

The attitude of many people towards a general principle may be illustrated thus: Let us suppose ourselves stand-

ing on the banks of a river and explaining the principle of gravity to an intelligent savage, illustrating the argument by the flow of the stream. He might reply: "You say that water always flows towards the centre of gravity by the line of least resistance, and that water, therefore, does not flow uphill. But see that back-eddy. If the stream is flowing downhill, the water which is flowing back upstream must be flowing uphill. Clearly you must be wrong."

We have here a principle and a general rule deduced from the principle. Our savage friend confounds the two. For while there can be no real exceptions to a principle properly so called throughout the class of facts to which it applies, there may be many exceptions to a general rule. In considering the facts, then, it should be borne in mind that we have a principle and a number of general rules deduced from the principle. While there can be no real exceptions to the principle throughout the class of facts to which it applies, there may be many exceptions to the general rules.

CHAPTER IV

ON NERVOUS ENERGY

THE nature of nervous energy is very obscure. The facts essential to the theory, however, may be noted by the intelligent reader in his own experience. The term "nervous energy" should not be confounded with the term "energy" when the latter is used in the sense of a well-developed liking and capacity for work. It would be difficult to excel the plodding industry of a Chinese peasant, but he is not conspicuous for nervous energy. An individual may be of a very indolent disposition and yet possess a highly charged nervous system. Such an individual will usually have a strong aversion to drudgery, but yet be capable of great exertions when stimulated by interest or necessity. This temperament is often associated with genius. Dr. Johnson was an example.

The amount of energy developed tends to proportion itself to the needs of the organism. If much is expended, much will be produced. If little is expended, little will be produced. If a man accustomed to heavy physical labour takes a holiday, he will find in his muscles a feeling of unusual strength. This is due to the accumulation of energy. If the holiday be prolonged, the feeling will gradually fade away; and if very prolonged, he may find, on resuming work, that it will take him some time to regain his full working capacity. This power of the organism to produce an increased supply of energy on

demand is taken advantage of in the training of athletes, the aim being to stimulate the production of energy by suitable exercises. Both mental and physical labour tend to the production of nervous energy; but if either is carried to excess, the resources of the system are unequal to the strain, and chronic exhaustion ensues. In countries having short hours of labour as much work is usually put through as in countries having longer hours. The capacity of the nervous system has its limits. Long hours soon show their effects in reducing the energy of the workers to a low ebb, and they have less time for recovery. As a consequence they work more slowly.

"According to Pfluger, when a nerve is stimulated, whether by a mechanical shock, an electrical discharge, or by the action of the will, a phenomenon occurs which this physiologist calls the *nervous avalanche*.

"Just as a lump of snow detached from a mountain-top grows as it descends the snowy slope, and when it reaches the valley is of larger size than when it set out, so the stimulus received by the nerve is multiplied in its passage through the conducting filament, and is much more intense when it reaches the muscle than it was when first produced.

"The nerve would then be a reinforcing as well as a conducting apparatus: it would increase the intensity of the stimuli which it transmits, as the microphone increases the intensity of the sounds which pass through it.

"If Pfluger's theory is correct, and if the nerve really has the power of amplifying the stimuli received by the muscle, we may believe that this power is developed by exercise like all the physiological functions of working organs. The motor nerves of a man who devotes himself

to bodily exercise should then become more capable of reinforcing voluntary stimuli." [1]

From this passage it would appear that the question as to whether the amount of nervous energy produced can be increased by exercise is regarded by physiologists as quite a debatable one. Yet that such is the case can be shown by a few simple considerations and a few simple facts. In the first place the power to regulate the supply to suit the demand is a necessary condition of the capacity of the organism for direct adaptation to its environment. For if the amount of energy produced by the system were a fixed quantity under all conditions, then no man, however much he was trained or practised, would be able to perform work which required more than a moderate expenditure of nervous energy, or if able to perform such work, when not doing so his system would be irritable with energy which would allow him no rest.

This is illustrated by a passage from the same writer: "When a vigorous horse has been kept in the stable for a long time, we see it when first brought out make leaps and turns, and show by its lively paces a great desire for movement. We then say that the animal is *frisky*. This great vivacity has not, however, as its sole object the manifestation of the joy it feels at being again at liberty: it expresses the *need for exercise* which the animal feels. Similarly, it is under the influence of the need for exercise that the wild beasts in a menagerie constantly prowl about their cages; that children coming out of the classroom leap and run about the recreation ground, and that dogs run after each other in the streets." [2]

The obvious explanation of this need for exercise is not that the animals referred to have an intelligent

[1] *Physiology of Bodily Exercise*, Fernand Lagrange, part i, chap. i.
[2] *Ibid.*, part v, chap. i.

realisation of the value of exercise, but that their nervous systems are irritable with energy which demands an outlet. In the above cases the nervous energy will have accumulated during the period of muscular inactivity. And if the supply is not utilised it will gradually abate and proportion itself to the amount used.

Thus the same authority continues: "But it is very necessary to yield promptly to the solicitations of this instinct, for the sense of need for exercise tends very soon to disappear if its satisfaction is delayed. If not heeded, it lessens day by day; if inaction is immoderately prolonged, it disappears entirely, and the time arrives when the organism which has too long led an inactive life shows a marked tendency to become more and more inactive. This is because too prolonged repose has brought about new organic conditions, uniting as it does all the circumstances which lead to the production of every kind of fatigue." [1]

Clearly, the disappearance of the sense of need for exercise is due to the fact that the nerves are no longer highly charged with energy.

An abundance of facts could be quoted to show that the amount of energy available is increased by exercise. Different kinds of athletic exercises lead to the expenditure of different amounts of nervous energy, and it is necessary to train for them by different methods. Thus sprint-running requires the expenditure of an enormous amount of nervous energy in a very short time. But long-distance running is rather a matter of muscular endurance. An appreciable interval of time elapses between the nervous discharge and the contraction of the muscle which follows, and it was established by Helmholtz that the length of the latent period is inversely proportional to the strength

[1] *Physiology of Bodily Exercise*, Fernand Lagrange, part v, chap. i.

of the nervous discharge. Therefore, to obtain more rapid contraction it is necessary to expend energy on a larger scale, and the swift sprint-runner expends a much larger amount of nervous energy in a given time than the long-distance runner.[1]

It would never do to train a man who is to run in sprint races on the same system as the man who is to run in long-distance races. Long-distance runners sometimes run in short-distance races with the object of improving their speed. They are usually given a long start, but are invariably hopelessly beaten. The sprint-runner is generally of a more highly strung type than the long-distance runner. The difference in the constitutional organisation required for exercises of speed and exercises of strength can be seen in the difference between a race-horse and a cart-horse. The muscles of the former cannot compare in bulk with those of the latter, but the race-horse is the very embodiment of nervous energy. The cart-horse, though possessing enormous muscular strength, is of a placid disposition and relatively deficient in nervous energy. If, then, speed depends rather on nervous energy than muscular strength, we can understand why a method of training suitable for long-distance running is not suitable for sprint-running. The exercises in the first case will be adapted to increase muscular endurance ; in the second case mainly to increase nervous energy. But if exercise does not increase the amount of energy available, a special form of training would practically be useless.

A prize-fight demands an enormous expenditure both of nervous energy and muscular strength. Throughout the whole fight the contestant must keep his muscles in a state which is known as "latent stimulation." The

[1] *Physiology of Bodily Exercise*, Fernand Lagrange, part i, chap. i.

muscles are stimulated but not contracted. This condition enables the fighter to reduce the period of latent contraction—the period which elapses between the stimulation and contraction of the muscle—to the lowest limit, since the already stimulated muscle contracts almost instantaneously on receiving the additional stimulus, and thus enables him to seize in a flash any opening that occurs. But this maintenance of the muscles in a state of latent stimulation requires an enormous expenditure of nervous energy. It would be clearly impossible for the fighter to expend energy on such a scale for such a length of time if his training did not increase the amount available. Quite apart from this question of latent stimulation, to train the muscles of a prize-fighter without increasing the amount of nervous energy available would be very like increasing the supply of dynamite cartridges without increasing the supply of detonators. The analogy is not quite exact, since the trained muscle contracts with greater force in response to a given stimulus, and thus economises nervous energy to a considerable extent. But such economy goes but a trifling way towards explaining the wonderful endurance shown by trained men in contests in which muscular strength and nervous energy are expended with the utmost prodigality, the nervous system being drawn upon more and more largely as the muscles become exhausted.

Again, the effects of exercise on the nervous system can be readily seen in the difference between the average town-bred man and the average country-bred man. The environment and occupation of the former call for considerable mental alertness and usually for activity of movement rather than the exertion of great muscular strength. The environment of the latter and his occupation call for no special mental alertness or activity of

movement, but usually necessitate considerable muscular exertion. The result is that the former is, as a rule, a man of less bulk but of greater nervous energy, the latter usually developing into a heavy, slow-moving, slow-thinking individual, conspicuously deficient in nervous energy. But this result could hardly be produced unless the nervous system and nervous energy developed with exercise. The greater quickness of movement which marks the town-bred man as compared with the country-bred man is obviously due to a greater expenditure of nervous energy, and this can only result from an increase of efficiency or of bulk, or both, on the part of the motor centres or the motor nerves, or both. Seeing, also, that the amount of energy developed is powerfully affected both by the nature of the food and the climate, it would be strange if exercise were the one factor by which it is not affected.

But there is a limit to the capacity of the organism for producing energy, and this is fixed by its inherent potentialities. Lagrange points out that exhaustion will result from work which is beyond a man's strength, even if he is well. He can perform such work only by "taking from his nerves" that which his muscles are unable to give. "The excessive exertion of the will in work leads to nervous exhaustion. It is thus that we see horses rapidly waste and get ill, if they are forced to draw too heavy a load, and their ardent and generous nature impels them to go on working up to the last limit of their strength."[1]

Probably, most of the physical deficiencies shown by the race in these days are the result of factory employment and similar occupations. Under the system of division of labour it is commonly asserted that this or

[1] *Physiology of Bodily Exercise*, Fernand Lagrange, part iv, chap. iii.

that occupation is "easy" because it looks simple and appears to call for no great muscular effort. But such work generally has to be executed very rapidly, and consequently necessitates a great expenditure of nervous energy. The result is that the factory worker, though employed at work which is called "easy," often suffers from nervous exhaustion at the end of the day's work, especially in hot weather.

The effects of nervous exhaustion are peculiar: "There occurs during an exercise of speed a nervous commotion resembling that which follows a strong emotion or a powerful mental strain. These results are especially marked in impressionable persons, and it is among them that we may see how fatigue caused by speed is adverse to the repair of the system. Many children, after running about too much, can neither eat nor sleep. Many horses which are too nervous refuse their oats after a hard day's hunting. We do not see this capricious appetite in coarsely built animals doing collar work all day." [1]

The symptoms above described are common among factory workers, especially during the hot months. It is also true that the more highly strung types are the more easily and the more often affected. When we reflect that boys and girls in their teens, the chief period of development, are worked all day at occupations which, although "easy," require a large and incessant expenditure of nervous energy, and that the result is often the loss of appetite and sleep, there is nothing strange in the fact that it often produces a marked deterioration in the physique.

The reason why the symptoms described above are more common in hot weather is because heat, and especially moist heat, has an exhausting effect on the

[1] *Physiology of Bodily Exercise*, Fernand Lagrange, part iv, chap. iv.

nervous system. Lombard has found that the power to perform voluntary muscular work is reduced by a decrease in the atmospheric pressure, and that several successive days of high temperature, particularly if accompanied by great humidity, are followed by a considerable loss of strength.[1]

Physiologists find that if a given point in a nerve be repeatedly stimulated, the response of the nerve becomes weaker after a time until it finally ceases. But if it be allowed to rest for a period new pulsations can be elicited. The nerve, while resting, becomes *charged* with energy. Evidently the intensity of this charge will at all times depend on the relation between production and expenditure. Now, the term "development" in our formula is hardly an adequate expression of the principle. The potential degree of fertility, at any given moment, will bear an inverse proportion, not to the amount of nervous energy developed or produced, but to the intensity of the nervous charge at that moment. The term "nervous charge" must not be taken literally in the sense in which a wire is charged with electricity. What goes on in the nerve is, as yet, an almost complete mystery. The phrase must be taken to apply to the nutritive condition which favours the production of energy, and is the best hypothetical statement of the case which can be given.

The nervous charge will be an approximately accurate reflection of the circumstances of the moment. "A" is a Society woman of means, and with little need for active exertion. She will produce a moderate amount of nervous energy, but will also expend moderately. Being highly fed, she will have a nervous system always highly charged. "B" is, say, a successful professional woman. She owes her success to a great natural fund of nervous

[1] *The Growth of the Brain*, H. H. Donaldson, chap. xiv.

energy. She expends on a large scale, but also produces on a large scale. She has a great capacity for work, which means that her system replaces the energy almost as fast as it is expended. She also will have a nervous system almost always highly charged. Thus one will have a highly charged system because she expends little, the other because she produces much. They may be equally fertile or infertile. "C" is, say, a sweated worker of the East End of London. She is over-worked for very long hours and under-fed. The result is that she is chronically tired and deficient in energy. Her nervous charge will be always low. If she is married, we may expect a large family.

The variation of the degree of animal fertility in response to the direct action of the environment will bear an inverse proportion to the intensity of the nervous charge.

The nature of the food consumed, both quantity and quality, will have a powerful effect on the amount of nervous energy produced. As Snyder puts it: "There is a close relationship between the nature of the food consumed and mental activity, also the ability to satisfactorily perform physical labour."[1] The effect of the quality of the food may be seen in the difference between a grass-fed and a corn-fed horse.

The chief constituents of food are broadly divided into—

Proteids.
Carbohydrates.
Fats.

There are also certain salts which play a part of some importance. The first of these classes is generally considered to be the main factor in the production of nervous energy. This view receives strong confirmation from

[1] *Human Foods*, Snyder.

the fact that races living upon foods poor in proteids are both deficient in nervous energy and very fertile.

Without entering into the controversy between the advocates of a meat diet and the vegetarians, it may be said that meat appears to be more stimulating to the nervous system. Of course, it must be borne in mind that meat is a complete food, whereas vegetables are not, so that the meat-eater is much less likely to be living on a diet short of some essential constituent than the vegetarian. But even allowing for that, a meat diet seems to be more stimulating. Giving evidence before the National Birthrate Commission, Dr. Starr Jordan mentioned that in the course of an experiment carried out at Stanford University of feeding rats, some upon a vegetable and some upon a meat diet, it was found that the meat-fed rats ran over 50 per cent. more ground than the others. That suggests a more stimulating effect from the meat. One authority says: "If proteid food, therefore, be regarded as a nervous food, a diet rich in it will make for intellectual capacity and bodily energy, and it is not without reason that the more energetic races of the world have been meat-eaters.

"The difference, in fact, between an animal fed on a highly nitrogenous diet, and one supplied with little nitrogen, is the difference between a steam-engine at half-pressure and one that is producing its full horse-power. It is the difference between a tiger pacing its cage and a cow lying upon the grass: both are healthy, but the type or degree of health is very different in the two cases." [1]

Quantity is of importance as well as quality. An under-fed man is very similar to an over-worked man. Both are deficient in nervous energy.

[1] *Food and the Principles of Dietetics*, Robert Hutchinson, chap. x.

Climate also has a very powerful effect upon the nervous system. A cold, dry climate is very favourable to the production of nervous energy, but it tends to be expended through the medium of physical exertion in the maintenance of heat. A cold, wet climate has a depressing effect unfavourable to nervous energy, and much of the bodily energy appears to be expended in maintaining heat. A hot, moist climate is very unfavourable to nervous energy. The climate of the West Coast of Africa leaves the average European as limp as a wet rag. Curiously enough, the climate of this region seems to leave the native black races comparatively unaffected. Perhaps this is due to the fact that their energy is mainly muscular. The climate of the United States is an example of one that is very favourable to the development of nervous energy. The children of stolid European peasants born and reared in the United States develop all the nervous activity of the children of native Americans. This is largely due, no doubt, to the bright dry air, as well as to a diet rich in proteids. A mild, dry, bracing climate is the one above all others which favours nervous energy. The effect is both direct, in its stimulating effect upon the nervous system, and indirect, through its influence upon the social habits of the people.

There is an optimum point for moisture and temperature as for all other environmental factors. Ellsworth Huntingdon, in his *Civilisation and Climate*, mentions that the data for New England show that extreme dryness does more harm than extreme humidity. Another point which he brings out is that the optimum point is not constant, but shifts continually. The optimum point of to-day is not the optimum point of to-morrow. A change of temperature is as beneficial as a change of air.

As nervous energy is a product of the nervous system, it

follows that a higher development of the nervous system will, other things equal, lead to a higher development of nervous energy; but quantity is not of so much importance as quality. Idiots sometimes have very large brains. Then there is the fact that brains increase in average size as we proceed northward—a fact which probably has something to do with the maintenance of heat. Again, there is what Herbert Spencer once called "a small brain in a state of intense activity." The possessors of the higher forms of intellect are often excelled in nervous energy by people of a lower intellectual order. The cerebral system being developed by exercise, an environment leading to incessant mental activity is favourable to the development of nervous energy. Mental activity does not necessarily mean study or any of the higher forms of intellectual effort. The complex environment of a modern city leads to an enormous and almost unsuspected amount of mental activity. The mind, and more particularly the unconscious mind, is constantly occupied in recording or acting upon myriads of suggestions which beat upon it from all sides. It is evident that the more complex the environment the greater will be the multitude of suggestions and the greater the multitude of cerebral reactions. Hence the larger brains, the greater mental activity, and the higher development of nervous energy in the average city man as compared with the average country man.

The amount of nervous energy produced is affected by many subtle influences. Thus bad news usually has a depressing effect, and tends to take the energy out of the average individual. Sometimes, however, it stimulates to feverish activity, as when news is received of a danger which may be avoided by exertion. The subtlety of the nervous force is seen in the ease with which a man of

genius will stimulate a vast body of men to intense activity by means of a few skilfully adjusted phrases. A mediocrity, on the other hand, will take all the spirit out of his followers with a little verbal clumsiness. Gloomy, insanitary and ill-smelling surroundings have a depressing effect on the nervous system. A bright, cheerful and pleasant environment has a very stimulating effect.

Thus we see that this subtle force is the most reliable measure of all the factors in the environment which make for survival or elimination.

The factors, then, which make for the maintenance of a highly charged nervous system may be broadly summarised thus :—

A complex environment leading to incessant mental activity.

A moderate amount of physical exertion.

A plentiful diet rich in nutriment in proportion to its bulk and rich in proteids.

A rather dry, bright, bracing climate.

Cheerful and pleasant surroundings generally.

As these are the factors which lead to a low deathrate, it follows that if the degree of fertility is to bear an inverse proportion to the survival-capacity of the race, it must vary inversely with these factors, and also, therefore, with nervous energy.

The principle when applied to the animal kingdom will need a similar qualification to that found necessary when applying it to the vegetable kingdom. Although it is a necessary condition of the success of the evolutionary scheme that a heavy deathrate should be accompanied by a heavy birthrate, yet there comes a time when an increased birthrate is no longer an advantage. In times of famine, for instance, it would merely add to the mischief. As the principle will be adjusted to the

needs of the species, it follows that the qualification will come into play when a further increase of the birthrate is useless. In point of fact, it is known that both famine and illness cause sterility.[1]

All this, of course, is merely another illustration of the principle of the vital optimum, and we may apply that principle to the variation of the degree of animal fertility thus :—

The variation of the degree of animal fertility in response to the direct action of the environment will be directly proportional to the intensity of the nervous charge until the optimum point for fertility is reached : it will thenceforward bear an inverse proportion to the intensity of the nervous charge.

[1] *Principles of Heredity*, Dr. Archdall Reid.

CHAPTER V

THE PRINCIPLE AS MANIFESTED IN THE ANIMAL KINGDOM

THE amount of evidence available as to the operation of the principle in the animal kingdom is comparatively limited. We are compelled to rely chiefly on the evidence supplied by the effect of change of environment on domesticated animals, and the effect of captivity on wild animals. It is of little use in this connection to make comparisons between the fertility of wild and domesticated animals. These latter have been adapted to the requirements of man by a course of selection extending over innumerable generations, and fertility is one of the attributes for which they have been selected.

It is true Darwin says that with "cats, ferrets, and dogs," and other animals "which are not valued for their prolificacy, selection can have played only a subordinate part"[1]; but to this it may be replied that prolificacy is always a valuable quality in a valuable animal. Experience with wild animals in captivity shows that when animals were first domesticated they would probably be relatively infertile. Darwin has himself shown that the principle of selection is in some measure understood even by primitive tribes. It is impossible to imagine that people who were capable of domesticating wild animals, an extremely difficult feat, would be blind to the fact that they would be more likely to obtain a large number

[1] *Variation of Animals and Plants under Domestication*, chap. xvi.

of these valuable animals by breeding from the more fertile rather than from the less fertile individuals. Even when individual merit is of more importance than numbers, the chances of obtaining a good specimen are obviously greater in a large than in a small litter. To this day fanciers who have to pay a large stud fee for the services of the best males will, as far as possible, use only females of proved fertility. If the litter is a small one, the chances of obtaining a good specimen are correspondingly small. If, on the other hand, the litter is a large one, the chances of obtaining a good specimen are correspondingly large, and the surplus can be disposed of.

In a wild state, it should also be borne in mind, the degree of fertility is largely governed by certain inherited instincts which determine at what period or periods, and how often during the year, the breeding activities shall be carried on. The theory under discussion is a theory of the laws which govern the union of sperm cell and ovum after copulation has taken place, and offers no explanation of the conditions which determine how or when it shall take place. Scientists are apt to expect too much from a general principle. Thus Spencer attempts to make his formula cover the whole field of animal and vegetable fertility. He attempts to make it explain those seasonal recurrences of the breeding instinct which can only be explained by inherited, instinctive associations.

The varying periods of gestation among animals render it necessary that copulation shall take place at different periods of the year in order that the young may be born at the most favourable season. These cases cannot be all governed by a simple physiological reaction. They must be governed by inherited instincts of the same character as the nest-building instinct or the migratory

instinct, and these instincts will be awakened by certain seasonal associations.

"At any rate it is not correct to say with Dr. Gruenhagen, that 'the general wedding feast is spring, when awakening nature opens to most animals new and ample sources of living.' This is certainly true of reptiles and birds, but not of mammals; every month or season of the year is the pairing season of one or another mammalian species; but notwithstanding this apparent irregularity, the pairing time of each species is bound by an unfailing law; it sets in earlier or later, according as the period of gestation lasts longer or shorter, so that the young may be born at the time when they are most likely to survive. . . . Far from depending on any general physiological law, the rut is then adapted to the requirements of each species separately." [1]

Under domestication, where warmth, shelter, and food can be obtained in abundance all the year round, these instincts tend to fall into abeyance, and domesticated varieties lend themselves readily to manipulation by man. Manipulation is, indeed, an important cause of the increased fertility of domesticated varieties. Thus when fowls become broody various ingenious devices are resorted to in order to get rid of the brooding instinct, such as putting the bird under a bucket. In some varieties of fowls the brooding instinct has been almost eliminated by selection.

We may now examine the evidence bearing upon the principle provided by domesticated animals. Darwin will again be the principal source of information. Speaking of race-horses he says: "During eleven years a record was kept of the number of mares which proved barren or prematurely slipped their foals; and it deserves notice as showing how infertile these highly nurtured

[1] *The History of Human Marriage*, Westermarck.

and rather closely inter-bred animals have become that not far from one-third of the mares failed to produce living offspring. Thus during 1866, 807 male colts and 816 female colts were born, and 743 mares failed to produce offspring. During 1867, 876 males and 702 females were born, and 794 mares failed." [1]

As the cases of the mares which slipped their foals are not separated from those where the mare proved barren, the actual degree of sterility is not clear, though it was apparently very large. This failure to distinguish between failure of instinct, failure of ovulation, failure of fertilisation, and cases of miscarriage impairs the value of much of the evidence collected by Darwin, and illustrates the necessity of a thorough analysis.

Perhaps the most conspicuous attribute of race-horses is a very high development of nervous energy. This they owe, partly to selection and inheritance, for they have been bred for speed for many generations, and speed is dependent rather upon nervous energy than muscular strength; partly, also, to the system of training and feeding. They are regularly exercised, which stimulates the production of nervous energy, and fed chiefly on oats, which have about the highest proteid content of any vegetable food. Of course, when the mares are taken for breeding this regimen is usually abandoned, and they are generally turned out to grass. Nevertheless, much of the effect must remain.

Another writer speaking of race-horses says: "At all events it is found in practice, that though the majority of maiden mares will become stinted while at work, yet that a large number require a run at grass before they become in foal." [2]

[1] *Descent of Man*, chap. viii.

[2] *The Horse in the Stable and in the Field*, Stonehenge, chap. xi.

The difference between a horse at work and a horse at grass amounts to this, that the former obtains regular exercise and is fed on a diet of corn. The exercise, if regular and not excessive, will, coupled with a diet which is very rich in proteids, and very nutritious in proportion to its bulk, stimulate the animal's system to a high development of nervous energy. The horse at grass feeds on the most bulky and innutritious of foods, a food consisting mostly of water and waste products and deficient in proteids. In order to satisfy its bodily needs it must be eating nearly all day. This bulky and relatively innutritious food entails a disproportionate amount of work on the part of the digestive system. With the corn-fed horse probably much more energy is expended, but far more is produced, and the animal, if properly managed, will invariably be in high condition. With the grass-fed horse, though little is expended, except in the disproportionate amount of digestive work, little is produced. The difference in the amount of energy produced by the corn-fed and the grass-fed horse is too notorious to need emphasising. Thus we see that conditions which lead to a high development of nervous energy are apt to cause sterility, whilst conditions the main effect of which is to reduce the amount of nervous energy lead to increased fertility.

Darwin mentions a fact which at first sight seems inconsistent with those detailed above. He says that "mares which have been brought up on dry food in the stable are often infertile when first turned out to grass."[1] Though Darwin does not give the fact on the authority of his own observation, yet it is probably correct. On the hypothesis under consideration it is susceptible of a very simple explanation. We have seen that the amount

[1] *Variation of Animals and Plants under Domestication*, chap. xvi.

of energy tends to proportion itself to the amount used. When the mare is first turned out to grass she will be in the high condition which comes of regular work and high feeding. The system will for a time continue to produce energy from its own resources on the same scale as before. Not being used, it will accumulate, and for some time the animal's system will be highly charged. The abatement will be gradual. After a time, not being used, and owing to the very bulky and relatively innutritious food, the supply will abate and the animal will become more fertile. This accumulation of energy is seen in horses which have been confined to the stable for a few days. When first brought out they are very "fresh" and often dangerous to drive until the surplus energy is worked off.

"Nervous, vicious animals are not so likely to breed as those of milder temperament. Aged animals, especially mares that have not been bred for some time, are extremely difficult to impregnate. This is well illustrated in the difficulty experienced in breeding mares that have been used for racing until they are ten or twelve years old. A large percentage of them fail to become pregnant. Mares that have been bred frequently often will continue to breed after they are twenty years of age. Fat animals are seldom good breeders, and it is often difficult to impregnate them. Animals intended for breeding should be in very moderate flesh. Active exercise just before the animal is fed is conducive to fertilisation."[1]

Vicious animals are usually nervous animals which have been spoiled when young through mismanagement. Nervousness is one of the signs of a highly developed nervous system. Witness the difference in this respect between the highly strung race-horse and the placid

[1] *The Diseases of Animals*, Mayo.

cart-horse. With the effect of old age on the degree of fertility there will be occasion to deal later.

Another writer says: "In the mare barrenness is equally due to a variety of causes. In a number of breeding studs the proportion of sterile mares has varied from 20 to 40 per cent." Among a number of other causes specified are "high condition (plethora) with profuse secretion and excitement, low condition, with imperfect maturation of the ova and lack of sexual desire."[1] Here we have both aspects of the principle clearly set forth. The same writer says again: "An irritable womb, with frequent straining, and the ejection of a profuse secretion, may sometimes be corrected by a restricted diet and full but well-regulated work. Even fatigue will act beneficially in some cases; hence the practice of the Arab riding his mare to exhaustion just before service."

This last fact is particularly significant. The Arabs have been famous horse-breeders for centuries. Probably the custom originally arose through the more or less accidental observation that the mare was more readily impregnated when fatigued. This observation would be confirmed by subsequent experience. Now the most obvious effect of fatigue is to exhaust the nervous energy of the animal. Doubtless there are other effects, but the fact fits in with the theory in a most striking way.

Discussing the best period for sending the mare to the horse, a writer says: "As, however, mares are very uncertain animals, he will do well to take advantage of the first opportunity after March, as by putting off the visit to the horse he may be disappointed altogether, or the foal may be dropped so late that winter sets in before he has acquired strength to bear it. These remarks

[1] *The Diseases of the Horse*, United States Department of Agriculture.

apply to maiden mares only; those which have dropped a foal are generally put to the horse nine or ten days afterwards, when almost every mare is in season. For this reason, valuable thorough-bred mares are often sent to foal at the place where the sire stands who is intended to be used next time.

"The mare then remains to be tried at intervals of nine or ten days, and when she is stinted the foal is strong enough to stand any length of journey with impunity."[1]

We have here recorded a fact which is noticeable with most breeds of domesticated animals. The maiden mare is a "very uncertain" animal. That is, she does not always come into season at the proper time, and when in season is apt to be very difficult to impregnate. When, however, a mare has dropped a foal, and has suckled the hungry youngster for nine or ten days, it is seldom that much trouble is experienced in getting her to conceive. Why? On the hypothesis under discussion it will be because the drain on the mare's resources will have diminished her nervous energy.

Cattle yield much the same evidence as horses. It is an interesting commentary on Herbert Spencer's theory that a condition of plethora is favourable to fertility that, after the first calf, cows are usually served when in full milk. A good milking cow in full milk is usually all points and angles. It is this condition which is most favourable to fertility; high condition being notoriously unfavourable.

Darwin says of sheep: "The amount of food affects the fertility of the same individuals; thus sheep which on the mountains never produce more than one lamb at a birth, when brought down to lowland pastures frequently bear twins. This difference apparently is not

[1] *The Horse in the Stable and in the Field*, Stonehenge, chap. xi.

due to the cold of the higher land, for sheep and other domestic animals are said to be extremely prolific in Lapland."

If sheep are very prolific in Lapland, the amount of food will hardly account for the relative infertility of mountain sheep, since Lapland is not exactly a land flowing with milk and honey. It appears to be a common notion that the small size of mountain sheep is due to scarcity of food. Even if mountain pastures were necessarily poor, it would not follow that the sheep would be badly fed. Sheep are run so many to the acre, according to its feeding value. Thus we have one-sheep, two-sheep, three-sheep pastures, and so on; while when the land is very poor it becomes a case of so many acres to a sheep. Mountain sheep are by no means ill-fed, and are usually quite fat when killed. If they were ill-fed they would not necessarily be small. Rather they would tend to be lean and bony. To what then shall we attribute their relative infertility?

Mountain sheep are very active. A writer says: "If there is one quality for which the mountain sheep is more remarkable than another, that quality is amazing activity; he can get over rough ground at a speed which would leave a Leicester sheep standing still, and his jumping powers are comparable with those of the deer."[1] These small-bodied, active animals bear much the same relation to the big-framed, sluggish lowland sheep as the small-framed and active townsman bears to the big, raw-boned, slow-thinking countryman, or as the small-bodied, energetic and active worker bee bears to the big-framed, sluggish queen bee. In short, they are conspicuous for nervous energy. This is probably due to the keen and bracing air of the high altitudes, and we need not be

[1] *Chambers' Journal*, December, 1911.

surprised that they are rather more fertile when brought down to the relaxing air of the lowland pastures.

In this connection some facts mentioned by Ellsworth Huntingdon are worth noting. "It is well known," he says, "that at high altitudes the number of red corpuscles in the blood increases enormously, and the capacity to absorb oxygen and give out carbon dioxide is correspondingly modified."[1] He quotes the experiments of Lehman and Pederson in Denmark and Norway, who found that a change of atmospheric pressure due to an ascent of two or three thousand feet made no appreciable difference to the strength of individuals as measured by the dynamometer, but that a similar descent is accompanied by a marked increase in strength which, however, disappears in about four days. It was suggested to him by Prof. H. E. Gregory that this may account for the fact that in the horse-races of the pioneer days of the south-western United States "the poor, scrawny animals brought down from the mountains by the Indians usually belied their appearance and outran the better-looking horses of the white man. They may have had an excess of red corpuscles." As the increased energy displayed lasts only four days, there is nothing in these facts inconsistent with the fact that mountain sheep become more fertile in the lowland pastures. But it becomes a question whether the increase of red corpuscles in the blood at high altitudes may not account, in some measure, for the greater activity of mountain sheep, and also for their relative infertility. It is true that the experiments showed no increase of strength during the ascent, but time may be needed for that. It is a remarkable fact that all mountain species seem to display this abnormal activity.

[1] *Civilisation and Climate*, p. 50.

Spencer states that a favourable pasture season in the autumn with ewes consequently in good condition is usually followed by a high degree of fertility in the following spring. As the weather most favourable to pasture is hot and moist, and as a hot, moist climate is very relaxing to the nervous system, this rather confirms our hypothesis. But the facts in this connection seem to require more precise observation.

The pig offers very similar evidence to the horse. The young sow, known to breeders as a "gilt," is generally put to the boar for the first time when from six to ten months old. It is at this time that difficulty is often experienced in getting her to conceive. The period of gestation is four months. She suckles her young eight weeks. When she parts with her litte. a good breeding sow is usually little more than a framework of skin and bone. It is in this condition that she is usually put again to the boar, and if this is done while she is still "poor" from the effects of suckling her previous litter it is seldom that any difficulty is experienced in getting her to conceive again; and she may go on breeding in this way to the end of her breeding career. If, however, she is allowed to reach a highly-fed condition before being put again to the boar, then trouble is likely to be experienced in getting her to conceive. High condition, as is well known among breeders, is inimical to fertility. It is true that Spencer attempts to establish a distinction between "normal" and "abnormal" plethora, but this is a piece of special pleading. As for the "inverse ratio between the degree of fertility and the cost of individuation," the domestic sow not only conceives best when in low condition, but actually puts on flesh during the period of gestation, so that by the time the young are born she is again in good condition. Thus the amount devoted

to individuation and the amount devoted to reproduction increase together.

"With all highly bred animals there is more or less difficulty in getting them to procreate quickly, and all suffer much from delicacy of constitution. A great judge of rabbits says: 'The long-eared does are often too highly bred or forced in their growth to be of much value as breeders, often turning out barren or bad mothers.'" [1]

Highly bred animals are, generally speaking, those which have been bred for qualities intimately associated with or the result of a high development of nervous energy. Vigour and grace of carriage, brightness of colouring, and most of the qualities valued by fanciers, are intimately connected with the vitality of the nervous system. A highly bred animal or bird is usually a "bundle of nerves."

Cats and dogs provide no special information beyond the general facts that with highly bred animals conception is likely to be uncertain and the litters very irregular in size, and that high-feeding and lack of exercise are likely to result in sterility. Together with several other domesticated species they are not manipulated in such a way as to throw any special light on the problem of fertility.

The domestic fowl, however, shows us the operation of the principle admirably. "Birds offer still better evidence of increased fertility from domestication; the hen of the wild *Gallas bankiva* lays from six to ten eggs, a number which would be thought nothing of with the domestic hen." [2] It is a notorious fact that domestic fowls owe their present high degree of fertility to long

[1] *Variation of Animals and Plants under Domestication*, chap. xvii.
[2] *Ibid.*, chap. xvi.

and careful selection. This selection is still going on, and we hear of 200-egg birds and 250-egg birds and so on. Yet these highly prolific birds are still subject to the operation of the principle.

The *potential* degree of fertility is inherited.

The *actual* degree of fertility is decided by the direct action of the environment.

"In Europe close confinement has a marked effect on the fertility of the domestic fowl: it has been found in France that with fowls allowed considerable freedom only 20 per cent. of the eggs failed; when allowed less freedom, 40 per cent. failed; and in close confinement sixty out of the hundred were not hatched." [1]

The question of importance from our present point of view is not the number of eggs laid but the number which are fertile. In the case of eggs which fail to hatch the whole sequence of reproductive phenomena is carried through except the union of the sperm cell with the ovum. There is no reason whatever to doubt that the sperm cells actually come into contact with the ovum. The fact that the egg is successfully laid shows that there is no obstruction to the passage of the sperm cells up the female ducts. Presumably, therefore, sterility is due to the effect of lack of exercise through the medium of the nervous system on the condition of the ovum, which, as a consequence, fails to admit the sperm cell. One of the principal effects of exercise is the expenditure of nervous energy.

If the reader sits on a fence and watches a number of fowls pecking and scratching for hours in a farmyard or field, he cannot fail to be struck by the immense amount of energy expended. And if, as is generally the case, such fowls are only partially fed and are expected to

[1] *Variation of Animals and Plants under Domestication*, chap. xviii.

pick up the rest for themselves, they will have a large amount of exercise with moderate feeding. Compare this with the case of the race-horse in training. The latter obtains plenty of exercise, yet is rendered less fertile. But the degree of fertility will be decided not by the amount of the exercise but by the effect of the exercise on the nervous system. The exercise of the race-horse is designed, in combination with a diet rich in proteids, to stimulate the production of nervous energy. The animal will expend much energy but will produce still more, and the degree of fertility in either case will be decided by the relation between production and expenditure.

Darwin provides a considerable quantity of evidence showing the effect of confinement upon the fertility of wild animals. He goes on to say: "Sufficient evidence has now been advanced to show that animals when first confined are liable to suffer in their reproductive systems. We feel at first naturally inclined to attribute the result to loss of health, or at least to loss of vigour; but this view can hardly be admitted when we reflect how healthy, long-lived, and vigorous many animals are under captivity, such as parrots, and hawks when used for hawking, chetahs when used for hunting, and elephants. The reproductive organs themselves are not diseased, and the diseases from which animals in menageries usually perish are not those which in any way affect their fertility. No domestic animal is more subject to disease than the sheep, yet it is remarkably prolific. The failure of animals to breed under confinement has been sometimes attributed exclusively to a failure of their sexual instincts; this may occasionally come into play, but there is no obvious reason why this instinct should be especially liable to be affected with perfectly tamed beasts, except indeed

indirectly through the reproductive system itself being disturbed. Moreover, numerous cases have been given of varieties which couple freely under confinement, but never conceive; or, if they conceive and produce young, these are fewer in number than is natural to the species." [1]

Observe that the effect of confinement on the fertility of wild animals is exactly similar to the effect of confinement on the fertility of the domestic fowl. There is, therefore, no reason to assume any mysterious psychological effect apart from the effects of high-feeding and lack of exercise. So, as fowls are more fertile when obtaining plenty of physical exercise and a moderate quantity of food, we should expect a similar result from wild animals in confinement. And this we do find.

"Notice has frequently been called to the fact that lions are so constantly bred and reared in the various travelling menageries under what most persons consider great difficulties and disadvantages.

"It must be borne in mind, however, that the circumstances under which they exist are most favourable to them, as they are constantly being roused and moved about from place to place, sometimes with a reduced quantity of food, until the courage and temper of the animals become perfectly African. The natural instinct and power being thus developed, the animals are far more healthy and vigorous than the fat, well-fed, lazy, sleepy occupants of the dens in the London Zoological Gardens." [2]

Thus we see that they react in exactly the same manner as the domestic fowl to similar treatment. They will no doubt be more healthy than the "fat, well-fed" animals in the London Zoological Gardens; but it is not a question

[1] *Variation of Animals and Plants under Domestication*, chap. xviii.
[2] *Wild Animals in Captivity*, A. D. Bartlett.

of health merely. They will produce more energy, but they will also expend more. There will be occasional spells of fasting or insufficient feeding which, together with the restless activity which results, will reduce the nervous charge very low. But the "fat, well-fed" animals will at all times have a nervous system highly charged with energy which they have no opportunity to work off.

Again: "The carnivora in the Zoological Gardens were formerly less freely exposed to the air and cold than at present, and this change of treatment, as I was informed by the former superintendent, Mr. Millar, greatly increased their fertility." [1]

This is much the same story. Exposure to the air and cold would lead to greater physical activity, and probably the cold would have a more direct effect by diverting some of the energy to the purpose of maintaining bodily heat. To anyone watching an animal in confinement prowling restlessly about its cage or flinging itself against the bars it is clear that the animal's system is highly charged with energy which can find no outlet. This feeling has been experienced by most people when confined to the house by wet weather or similar causes. The effect of low temperature in this connection is well stated by Lagrange: "The need for exercise is developed with more intensity in proportion to the lowness of the temperature; by severe and piercing cold we are much more driven to action than by great heat. In this case the need for exercise is derived from the instinct which leads us to produce heat by movement." [2]

Darwin mentions the great longevity of parrots and the fact that even in England they are believed to have

[1] *Variation of Animals and Plants under Domestication*, chap. xviii.

[2] *Physiology of Bodily Exercise*, Fernand Lagrange, part v. chap. i.

lived to the age of nearly one hundred years, and adds: "yet they breed so rarely, though many have been kept in Europe, that the event has been thought worth recording even in the gravest publications." [1]

The difference between the life of a wild parrot and that of a parrot in confinement amounts to this, that when wild the birds lead an active life in searching for their food and playing about among the branches of the trees, and the food will consist mostly of berries and fruits of various kinds, bulky and poor in proteids. In confinement they lead a life of comparative inactivity and are highly fed on foods rich in proteids. A considerable measure of sterility, therefore, is to be expected under confinement.

In this case, as in others, we should expect that when given a larger measure of liberty they would prove more fertile. And we are told that "when Mr. Burton turned out a large number of parrots in Norfolk, three pairs bred and reared ten young birds in the course of two seasons; and this success may be attributed to their free life." [2] Apparently the birds were regularly fed in this case. Had it been possible for them to have picked up their own living, the results would probably have been greater.

The parrot is a long-lived, slow-breeding bird of high cerebral development, as its well-known intelligence shows. Now, we should expect to find that confinement has an effect corresponding to the measure of normal fertility. A very fertile type would have its fertility impaired but not wholly destroyed by captivity; while a relatively infertile type would become almost completely sterile. Thus we can understand the almost complete

[1] *Variation of Animals and Plants under Domestication*, chap. xviii.
[2] *Ibid.*

sterility of the parrot. The effect, too, would be proportionate to the change in the habits of the species from an active to an inactive life, and also proportionate to the change from a poor diet to a rich one. For if a species lives under hard conditions the optimum point for fertility will be adjusted to hard conditions. These considerations throw considerable light on certain facts mentioned by Darwin :—

"We have seen that carnivorous animals are more fertile under confinement than most other mammals. The reverse holds good with carnivorous birds."[1] The change in the habits of the birds is much greater. The animals are able to obtain a certain amount of exercise in confinement. The birds, accustomed to traverse vast distances when at liberty with meals uncertain and often far between, can do little in captivity but mope upon a perch all day. Add to this that they will be well and regularly fed. The tiger is, weight for weight, far stronger and more formidable than the lion. This points to a higher development of nervous energy. Consequently we need not be surprised when we are told that the tiger is much less fertile in captivity than the lion.

"The carnivora, with the exception of the Plantigrade division, breed, though with conspicuous exceptions, about half as freely as ruminants."[2] This represents about what we should expect in view of the greater change in the habits of the carnivora. These latter are more conspicuous for nervous energy than the herbivora. A lion or a tiger bears much the same relation to an antelope or other herbivorous animal that a sprint runner bears to a long-distance runner. The former are capable of putting forth an enormous amount of nervous energy

[1] *Variation of Animals and Plants under Domestication*, chap. xviii.
[2] *Ibid.*

in a very short space of time, but their energy is not enduring. They will usually outrun a herbivore in a short burst of speed, but they cannot stand the distance. When at liberty they expend their energy in seeking and stalking their prey, and they often experience long fasts between meals. In captivity they have little opportunity or necessity for exercise, and they are well and regularly fed. Their meals are of meat, which is one of the richest in proteids of all foods. The herbivorous animals will be little better fed in captivity than in a wild state, and the difference will lie chiefly in the amount of the exercise.

"The most notorious case of an animal not breeding in captivity is that of the elephant. Elephants are kept in large numbers in their native Indian home, live to old age, and are vigorous enough for the severest labour, yet, with few exceptions, they have never been known even to couple, though both males and females have their proper periodical seasons."[1] In this case failure to breed seems to be mainly due to failure to couple, rather than to actual sterility. With such unwieldy animals coupling is a serious business, not to be lightly undertaken, a fact of which the animals themselves are probably not unconscious. Therefore it is probable that the failure to couple is mainly due to lack of opportunity under favourable conditions. It may, of course, be due to some failure of the sexual instinct.

Elephants in India are usually fed partly on a corn diet, and between a wild elephant and one in captivity there is a difference very similar to that between a grass-fed and a corn-fed horse. And when the elephant is treated in the same manner as a grass-fed horse, it also becomes more fertile. Proceeding "a little eastward to Ava, we hear from Mr. Crawfurd that their 'breeding

[1] *Variation of Animals and Plants under Domestication.* chap. xviii.

in the domestic state,' or at least in the half-domestic state in which the females are generally kept, is of every day occurrence." [1] This is attributed to the female being allowed to "roam the forest with some degree of freedom." Thus there is nothing very mysterious in their failure to breed under the ordinary circumstances of captivity.

The same general phenomena are displayed by captive birds. "Of the small graminivorous birds, many kinds have been kept tame in their native countries, and have lived long; yet, as the highest authority on cage birds remarks, their propagation is 'uncommonly difficult.'" [2] The change in the habits of these birds is from an irregular and uncertain diet upon seeds of poor quality to regular feeding upon seeds of the highest feeding value: from a life of incessant activity to a life of comparative inactivity. They show the general law in that they are more fertile when kept in large aviaries, where they can obtain a fair amount of exercise, than when they are kept in small cages. Canaries, which breed freely in captivity, have had their potential degree of fertility increased and adapted to the conditions of captivity by selection. Nevertheless, they produce large numbers of infertile eggs, particularly highly bred birds.

The gratuitousness of the "race-suicide" theory is admirably shown by several passages from Darwin. "Monkeys, in the nine-year report from the Zoological Gardens, are stated to unite most freely, but during this period, though many individuals were kept, there were only seven births." [3] We see that conception does not necessarily follow union. The females, when coupling took place, must have been impregnated with large

[1] *Variation of Animals and Plants under Domestication.* chap. xviii.
[2] *Ibid.* [3] *Ibid.*

numbers of sperm cells. Many of these must have come into contact with the egg cells. Why then is conception under such conditions so infrequent? There seems no escape from the conclusion that the result is due to the effects of high feeding and lack of exercise, through the medium of the nervous system, on the condition of the germ cells. And if human beings are subject to the same biological laws as the lower animals, then a similar combination of causes should be followed in their case by similar effects.

Again: "Although so many of the Felidæ breed readily in the Zoological Gardens, yet conception by no means always follows union; in the nine-year report, various species were specified which were observed to couple seventy-three times, and no doubt this must have passed many times unnoticed; yet from the seventy-three unions only fifteen births ensued."[1]

We have already seen that horses which have been brought up on dry food in the stable, and no doubt systematically worked during that period, are apt to be infertile at first when turned out to grass. An analogous phenomenon is reported by Darwin of wild animals in captivity. "Those animals which usually breed freely under confinement, rarely breed, as I was assured, within a year or two of their first importation."[2] When mares are turned out to grass they are able to obtain plenty of exercise in the field, and the change of diet is from one of very high feeding value to one of very low feeding value. In spite of this the animal's system will continue, for a time, to produce energy from its own resources on the same scale as before, and the abatement will be gradual. The same phenomenon in the case of wild animals

[1] *Variation of Animals and Plants under Domestication*, chap. xviii.
[2] *Ibid.*

in captivity will be much more pronounced and of longer duration. They will be reduced to a life of the utmost inactivity and well and regularly fed upon rich foods. It will take a long time for an animal's system to adapt itself to such a change.

Darwin gives a number of instances showing that insects are also liable to show diminished fertility as a result of confinement. But the most remarkable support is given to the theory by the cases of ants and bees. It is surely no mere coincidence that the most conspicuous examples of cerebral development and nervous energy throughout the insect world should be almost wholly sterile, and that the fertile members of the ant and bee communities are conspicuously deficient in those intellectual attributes for which their sterile relatives are famous. It is an established fact that a fertile, big-bodied, and sluggish queen, or an infertile, small-bodied, and active worker may be developed at the will of the nurse bees from the same fertilised egg if taken within a few days of being laid. All the larvæ are fed upon the same milk-like pap for the first three days or so, but after that the workers are weaned and placed on sparser and plainer diet. Those intended for queens, however, are fed sumptuously on the original brood food, under the stimulus of which they grow much bigger than the workers and develop an enormous fertility. But what they gain in size and fertility they lose in energy and brain development. The workers, reared on a diet of honey and pollen, develop great brain power and energy, but what they gain in these directions they lose in size and fertility. We shall see later that these facts are paralleled by similar facts in the human race, and we have already seen a somewhat similar example in the case of mountain sheep. But it is necessary to point out that sterility in the case

of worker bees is not due to the law which governs the union of sperm cell and ovum, but that there appears to be a complete failure of the sexual instinct and of ovulation.

Ants exhibit the same phenomena as bees. The sterile workers are among the most remarkable examples of cerebral development in the insect world, and Darwin considered the brain of an ant to be the most wonderful speck of matter in the world. The fertile females show the same intellectual deficiency as the queen bee. The female of the white ant loses even the power of locomotion, grows to an enormous size, and becomes a mere egg-producing machine.

In his *Variation of Animals and Plants under Domestication* Darwin provides a mass of evidence bearing on the problem of fertility. The first impression produced on examining this evidence is one of hopeless confusion. The facts appear to be a mass of contradictions and to conform to no law. When, however, we apply the principle of the vital optimum and get the abstract principles straightened out the facts fall readily into line. It is a necessary deduction from the theory of organic evolution that the animal and vegetable kingdoms are governed by the same general biological laws, and the facts in the two cases are exactly parallel. Plants are rendered sterile both by excessively favourable and by excessively unfavourable conditions, and the same is true of animals. Plants are apt to be rendered less fertile when first transplanted into the more favourable conditions of cultivated gardens, and wild animals are rendered less fertile when first confined and highly fed. Plants may have their fertility greatly increased by selection, and the same is true of animals. Both may be adapted to develop a high degree of fertility under

favourable conditions, but both show that they still remain subject to the law by becoming infertile when the conditions become *too* favourable. As plants can be rendered sterile by high cultivation, so animals may be rendered sterile by high breeding. But there is some difference in the facts affecting the last case as between plants and animals.

In the case of asexually propagated plants the action of the principle is not antagonistic to the effects of selection, whilst those plants which are propagated by seed are not, as a rule, selected for qualities which are peculiarly antagonistic to fertility. But among domesticated animals there is no such thing as asexual propagation, and the animals are often selected for those very qualities which are most antagonistic to fertility, the qualities, in fact, most intimately associated with nervous energy.

In the case of the race-horse, for example, we see two antagonistic tendencies at work. The most fertile mares will, of course, produce the most young, but the owner will desire to secure foals from the most successful racers, and will make special efforts to do so. The effects of breeding for speed will in some measure be counteracted by the selection of the most fertile mares; but in the case of asexually propagated plants the principle has full play. So in the one case the result is merely diminished fertility, and in the other almost complete sterility.

Darwin mentions a number of peculiar and apparently capricious facts, but nothing inconsistent with the principle. While some species are rendered almost completely sterile in captivity, others breed freely under the most unnatural conditions. This latter result is probably due to some peculiarity of constitutional organisation. Thus we know that some individuals are powerfully affected by changes of climate and others are not. One individual may be

rendered limp and exhausted by a hot, moist climate, while another scarcely seems to notice it. We know that the body is provided with a heat-regulating apparatus which drives the blood into the interior of the body in cold weather, and thus conserves heat; while when the weather is hot the capillaries on the surface of the body expand, thus allowing the blood to come to the surface and radiate heat. If in one individual or species the regulating apparatus is very efficient and in another relatively inefficient, there will obviously be a great difference in the way they react to changes of climate, and there may be a corresponding difference in the degree of effect upon their fertility. And this will apply to other factors beside climate. So these apparently capricious results are in no way inconsistent with the general law, and, in view of the tremendous complexity of the factors at work, are to be expected.

It may be pointed out here that we have only to assume that human beings are subject to the same general biological laws as animals and plants, and we have an adequate explanation of the declining birthrate. For the main effects of advancing civilisation and increasing prosperity are cerebral development, with ever-increasing nervous energy, high feeding, and diminished physical labour. The human race is tending more and more to resemble the highly bred race-horse, and to be subject to a similar condition of feeding and training. So if sterility appears in the race-horse in spite of the effects of careful selection, what shall we expect in the human species when the same tendencies and conditions are reproduced in a highly accentuated form?

CHAPTER VI

THE PRINCIPLE AS MANIFESTED IN HUMAN SOCIETY

In applying the principle to human society it will be well to set forth certain general rules embodying the results we should expect to find. The principle is that the degree of fertility at any given moment will be inversely proportional to the intensity of the nervous charge. This requires a qualification similar to that found necessary in applying it to the vegetable world; but in human society the qualification is only likely to become operative in actual famine conditions. As these are very rare, it will be possible, for practical purposes, to ignore the qualification and consider the degree of fertility as varying inversely with the development of nervous energy. We have seen that the factors which make for a high development of nervous energy are—

A moderate amount of physical exertion.

A plentiful diet rich in nutriment in proportion to its bulk, and rich in proteids.

A bright and bracing climate.

A bright and cheerful environment generally, with plenty of mental stimulation.

From these may be deduced the following general rules to which we may expect the facts to conform.

Generally speaking, the birthrate and the deathrate should rise and fall together.

In comparisons between different countries, the most wealthy and progressive should be the least fertile.

As a nation becomes more civilised and wealthy the degree of fertility will tend to decline.

As we ascend the social scale the degree of fertility will steadily diminish with the increase of wealth and prosperity.

In the fluctuations of a nation's prosperity periods of depression should show an increasing birthrate, whilst periods of prosperity should show a decline.

These are general rules, from which, owing to the complexity of the factors, we may expect many exceptions.

It is obviously only through the operation of the law of averages that such a principle can make its action apparent. There are enormous differences between the habits of individuals belonging to the same social class. The degree of fertility is subject to variation between individuals like all other inherited potentialities. Also there appears to be considerable variation in the penetrating power of the male cells. Thus the factors provide for an enormous range of variation in individual cases. But the law of averages will level up these individual idiosyncrasies, and comparative statistics will show clearly the operation of the principle.

Demographers have long noticed the general correlation between birthrates and deathrates, and many attempts have been made to explain the connection; but some writers, in view of the fact the correlation is not uniform, are inclined to deny that there is any real connection. A favourite method of explaining the fact that a falling deathrate is accompanied by a falling birthrate is to reverse the proposition and assert that a falling birthrate is accompanied by a falling deathrate owing to the much smaller infantile mortality in small families. This, how-

ever, is an altogether inadequate explanation. France, a country of small families, has a high infantile deathrate; while Ireland, where the people are still fertile, has a low one. The falling birthrate in England during the last quarter of the last century was accompanied by a rising infantile mortality, the fall in the deathrate being due to the saving of life during later years.[1] Moreover, large families among prosperous people are not accompanied by a heavy infantile mortality.

In this connection some striking facts were mentioned by Dr. Halford Ross, in his evidence before the National Birthrate Commission, which came under his notice while Health Officer in the Suez Canal Zone. "During the years 1901 to 1910 health measures in this zone produced a very considerable fall in the deathrate, from 30·2 per thousand to 19·6 per thousand; the infant mortality was also reduced very greatly, and it was expected that, after a lapse of time, the reduction of the deathrate would result in a rise of the birthrate, and a corresponding increase in the population. But such was not the case. When the deathrate fell, the birthrate fell too, and the number of the population remained the same as before, even after nearly a decade had passed, and notwithstanding the fact that the whole district had become much healthier, and one town, Port Said, was converted from an unhealthy fever-stricken place into a seaside health resort. . . . From these observations it would seem that there is a constant correlation between birthrates and deathrates. As one increases, the other increases; and if one is reduced, the other falls. In a certain place a serious epidemic of plague occurred in 1907. The deathrate rose higher than the birthrate for three weeks, but very soon the birthrate rose and regained its former

[1] *The Task of Social Hygiene*, Havelock Ellis.

relation with the deathrate, which remained high for a time. Then both fell together to their original level as soon as the plague disappeared. A similar correlation of birthrate and deathrate was noticed in Cairo in 1910 during a severe fatal outbreak of small-pox. This correlation of births and deaths makes any measures taken to modify their rates appear futile, because their relationship seems to follow a natural law, which at present is not understood."[1] It would be interesting to know how these facts could be explained on the "race-suicide" hypothesis. Are we to assume that the population promptly took to the use of contraceptives as soon as the deathrate fell, although they did not think it necessary to use them before?

An excellent test case showing the operation of the general law that birthrate and deathrate vary together under circumstances where it would be absurd to appeal to the use of contraceptives for an explanation is provided by India. Here are figures showing birthrates and deathrates among the various provinces of that country:[2]

	Births.	Deaths.
Bengal	37·32	36·08
United Provinces	40·22	39·07
Punjab	43·70	36·94
Central Provinces	51·72	43·47
Lower Burmah	32·33	27·15
Eastern Bengal and Assam	37·38	31·67
Madras (Presidency)	30·90	27·40
Bombay (Presidency)	33·84	35·06
North-West Frontier Provinces	38·60	33·73
Coorg	26·80	29·26
Ajmer Merwara	27·50	32·22

The accuracy of these figures is not guaranteed, and they are compiled upon the method of giving the number of births per thousand of population, which is very misleading as a guide to fertility, instead of the number of births per thousand married women. Yet in spite of

[1] *Problems of Population*, p. 382 *et seq.* [2] *Racial Decay*, Beale.

these defects the general correlation between birthrates and deathrates is remarkable. M. Muret, writing in 1766, was so struck by the fact that a low deathrate is always accompanied by a low birthrate—a fact ascertained by him as the result of careful researches in Switzerland—that he hazarded the conjecture that "God has wisely ordered things in such a manner that the force of life in each country should be in the inverse ratio of its fecundity."[1]

It is in comparing the rates for large areas that the correlation is most readily traced, and that is because the principle will act through the law of averages. The larger the area, the more effectively do disturbing factors in either direction counterbalance and cancel each other. If a number of towns be taken, while there is still a general correlation between birthrates and deathrates, there is a great deal of irregularity. Much of this is simply statistical. Movements of population profoundly affect statistical results, especially when the figures are compiled upon the system of showing the rates per thousand of population. For instance, tables compiled upon that method credit Australia and New Zealand with a higher birthrate than Ireland. The reason is that there is a large emigration from Ireland and a large immigration into Australia and New Zealand. This leaves Ireland with a disproportionate number of old people and children in the population left behind, since emigrants consist mainly of young people in the prime of life. For the same reason new countries like Australia and New Zealand have a disproportionately large number of inhabitants of child-bearing age, and also a better balance between the sexes. And when tables are given which make the necessary allowances for these facts it is found that Ireland has a very high rate of fertility, while Australia

[1] *The Principle of Population*, Malthus, Book II, chap. v.

and New Zealand have very low rates, as we shall presently see.

Now, the connection between birthrate and deathrate is only indirect. Let us suppose that a certain municipality provides an excellent supply of pure milk and thus cuts down the rate of infant mortality. As this will not affect the adults, there is no reason why it should affect the birthrate. And now let us suppose that another municipality, through some neglect, causes a considerable increase of infant mortality which does not affect the birthrate either. This will cause a big discrepancy between the birthrate and deathrate correlation for the two towns. Yet when the rates for the country as a whole are worked out these two factors will counterbalance and cancel each other. That is why the operation of the principle will always be more clearly seen in comparisons between large areas, particularly between different countries. It will manifest itself through the law of averages. And while it will be true that the same combination of causes which leads to a high deathrate will lead also to a high birthrate and vice versa, yet there will always be a considerable number of factors which affect one without immediately affecting the other. But the law of averages will ensure that these factors in the long run will balance each other, and thus we shall get comparatively uniform correlations in comparisons between large areas or long periods of time, coupled with many irregularities in comparisons between small areas or short periods.

This is what we do find. The correlation in comparisons between countries is remarkably uniform considering the imperfection of our statistics, while the correlation between towns, though showing the operation of the law in a general way, is very irregular. The regularity

of the correlation on the whole is quite good enough for the purposes of evolution, and it would be absurd to expect mathematical regularity. There are a few apparent exceptions to the general law that a declining deathrate is accompanied by a declining birthrate. For instance, during the first half of last century the figures for England show a rising birthrate and a declining deathrate. But the difference is small, and it is quite probable that the apparent increase of the birthrate was due to improvements in registration.

A more difficult case is that of Ireland, where, according to results obtained by Dr. T. H. C. Stevenson,[1] there has been a marked rise of fertility, even when the necessary allowances are made for the peculiar constitution of the population as regards age and the number of young married women. Assuming that all necessary statistical factors have been taken into account, it is hardly possible to express an opinion as to what may be the cause of this peculiar result; but it may be taken as fairly certain that it is not to be found in religious influences, as Dr. Stevenson suggests. It may be laid down as one of the fundamental principles of sociology that the average man will react to average circumstances in an average manner. And whenever some special result is produced this must be the result of special causes. An increase of the birthrate in Ireland is just as much in need of explanation from those who believe that the fluctuations of the birthrate are the result of deliberate restrictive measures as from those who believe that these matters are governed by natural laws. The almost universal experience of mankind in all ages is that with increasing prosperity and a declining deathrate the birthrate also declines, and this is as true of Roman Catholic as of other countries.

[1] *The Declining Birthrate*, p. 350 *et seq.*

If, then, Ireland is an exception to this almost universal rule, such a special result must be due to special causes. A very little reflection is sufficient to show this, for if the birthrate is rising, what was keeping it down before the rise commenced? Were contraceptives being used, and is their use now diminishing under the influence of religion? Rises in the birthrate are very frequent phenomena in the world's history, but advocates of the "race-suicide" view seem never to reflect that an explanation is needed. A decline needs an explanation which they endeavour to provide, but an increase just "happens to occur." These cases of apparently increased fertility in opposition to the general law need much more minute investigation, and superficial attempts at explanation are useless.

The increase of fertility in Ireland, if genuine, may perhaps be due to the fact that the peasantry, now owning their own farms but encumbered by debt, are working very hard to get the debt paid off, after the manner of thrifty peasants the world over, their wives taking a considerable part in the work. But the birthrate figures for Ireland for the period from 1903 to 1913 are given in the *Statistical Abstract* as follows:—

Year.	Rate per 1,000 of Population.
1903	23·1
1904	23·6
1905	23·4
1906	23·5
1907	23·2
1908	23·3
1909	23·4
1910	23·3
1911	23·2
1912	23·0
1913	22·8

Thus the crude birthrate shows a slight decline up to the beginning of the war, and if this really represents a substantial increase of fertility, there must have been

an enormous increase in the proportion of old people and children in the population as the result of emigration, and this is somewhat dubious as a sign of that increased prosperity to which Dr. Stevenson attributes the alleged increased fertility. But this apparent increase appears to be the result of very refined mathematical calculations based upon very imperfect data. Apparently more complete proof is needed before much dependence can be placed upon it.

The principle implies that in comparisons between different countries the wealthiest and most highly civilised will have the smallest birthrates. The following table[1] showing the birthrates for many of the chief countries of the world is by Drs. Newsholm and Stevenson, and is corrected to allow for the varying numbers and ages of wives in the population :—

	Corrected Birthrate per Thousand of Population.			
	Legitimate.		Total.	
	1880–1.	1901–4.	1880–1.	1901–4.
Austria	39·04	32·84	42·86	38·50
Bavaria	39·55	35·59	45·49	40·39
Belgium	38·06	28·85	40·76	31·01
Denmark	35·36	29·94	38·92	33·12
England and Wales	32·73	27·29	34·65	28·41
France	22·73	19·29	25·06	21·63
German Empire	36·44	32·01	40·37	35·34
Ireland	34·59	35·39	35·17	36·08
Italy	33·40	31·17	36·89	33·71
New South Wales	36·53	24·61	38·80	26·47
New Zealand	34·88	28·44	36·68	29·63
Norway	37·59	35·62	49·12	37·79
Prussia	36·54	32·72	39·87	35·72
Saxony	35·05	26·60	41·45	31·76
Scotland	36·47	31·65	39·29	33·38
Sweden	35·56	32·90	38·49	36·19
Victoria	34·25	25·77	36·02	27·04

[1] *The New Dictionary of Statistics*, Webb.

This table shows that the highest birthrates are usually found in the poorest countries. The Russian birthrate (not given in the table) is the highest in Europe, and the Russian peasantry are the poorest and most oppressed. The results are probably powerfully affected by the climate. The inhabitants of all countries having a dry, bright, sunny climate show a marked intellectual vivacity and a tendency to "nerves." On the other hand, the inhabitants of countries having a colder, moister climate are, other things equal, of a more stolid disposition. If we take the factors wealth, a bright climate, and a diet rich in proteids as the principal factors making for nervous energy and a low birthrate, we shall be fully borne out by the facts. France, America, and Australia are conspicuous for all these factors, and those are the countries where the birthrate is falling most rapidly. Italy has a somewhat lower birthrate than her poverty would lead us to expect, and this may be due to her climate. Those countries which are prosperous industrially, but have a colder and moister climate, have also a somewhat higher birthrate. England, as being more prosperous than Germany, has a lower birthrate, but with the advance of industrial prosperity Germany's birthrate is rapidly falling. The highest birthrates seem to be found where poverty, ignorance, and a moist climate go together.

With certain doubtful exceptions, all countries where the mass of the population are very poor and have a hard struggle for existence have an enormous birthrate. The poorer classes of Chinese, for instance, live a hand-to-mouth existence on a trifling quantity of rice and such scraps of garbage as their infinitesimal resources will enable them to purchase. For this they have to labour terribly hard. So far as I am aware, no figures are available for the birthrate, but the deathrate is gigantic,

especially among the children. "One missionary canvassed his district and found that nine children out of ten never grew up. Dr. McCartney of Changhang, after twenty years of practice, estimates that from 75 to 85 per cent. of the children born there die before the end of the second year. The returns from Hong-Kong for 1909 show that the number of children dying under one year of age is 87 per cent. of the births within the year. The first census of Formosa seems to show that nearly half the children born to the Chinese there die within six months." [1]

Nor is this the whole story. The country is continually devastated by wars, plagues, floods and famines which sweep away the people like flies. The birthrate, therefore, must be enormous, for the average numbers of the people remain undiminished. Japan is also very poor and very fertile.

Speaking of the Cape Boers, Herbert Spencer quotes the traveller Barrow as saying: "Unwilling to work and unable to think . . . indulging to excess in the gratification of every sensual appetite, the African peasant grows to an unwieldy size;" and of the women Barrow says: "The women of the African peasantry lead a life of the utmost inactivity." Then, after illustrating these statements, he speaks of "the prolific tendency of the African peasantry. Six or seven children in a family are considered very few; a dozen to twenty are not uncommon." [2]

Probably the remarks concerning the inactivity of the Boer women are exaggerated. In very few parts of the world do farmers' wives lead a life of idleness. No doubt Kaffir servants are plentiful, but their labour is not of a kind to be trusted far without supervision. In

[1] *Century Magazine*, July, 1911, E. A. Ross.
[2] *Principles of Biology*, vol. ii, part vi, chap. v.

contemplating these big-framed, slow-thinking people, possessing very little nervous energy, and very fertile, it is impossible not to be struck by the analogy with the big-framed, sluggish queen bee. Take an average married couple and place them in the midst of a large city with a comfortable income, and their children will probably grow up into men and women of medium physique, of active habits, both mental and physical, and of very moderate fertility. Place the same couple away in the back-veldt of South Africa, leading a life of extreme simplicity, and with plenty of simple food, and their children will grow up into big-framed, sluggish-minded, and very fertile individuals.

People of all races who lead a simple and mentally inactive life seem to develop big frames, provided, of course, that they are also well fed. Even among small peoples, such as the Japanese, the country people are of large physique compared with those of the towns. A complex environment leading to incessant mental activity results in smaller physical development, other things equal. It appears that nutrition is diverted from the muscular tissues and bony framework to the purpose of maintaining the costly nervous system.

Of course, nervous development does not necessarily lead to a small stature. Much will depend on the amount of food, and also the inherited type. The Americans, who are conspicuous for nervous energy, are a bigger race than the French, and a much bigger race than the Japanese, who, taken as a race, are not an outstanding example of nervous energy. But the Americans are big eaters, particularly of meat, one of the richest in proteids of all foods. The French are somewhat frugal eaters, whilst the rations of the Japanese are notoriously small. Again, it is observed that the wealthy classes

in England are usually of somewhat better physical development than the working classes, in spite of greater nervous development. But, apart from study, the children of the wealthier classes do no work. They have plenty of games and other amusements, and are highly fed. The children of the workers, on the other hand, are generally occupied in exhausting labours for about ten hours a day during their teens. Their work in factories is often such as to involve an immense drain on the nervous system, and they are not always well fed. The question seems to be largely one of the amount of nutrition available and its proportionate distribution.

It is probable that whilst the difference in stature between the average countryman and the average townsman is a difference of the reaction of the organism to the environment, the difference in stature between such peoples as the Americans and the Japanese is one of inherited type. If we glance round the world we see that some mountain races, such as the Ghurkas, are small, while others, such as the Pathans, are tall. The gradual increase of stature among most civilised races illustrates the difference between the inherited type and its reaction to the environment. Though the direct action of a complex environment appears to develop the cerebral system at the expense of the rest of the organism, yet the type itself is growing taller. It is possible that this increase represents the effort of Nature to provide a better foundation for the rapidly developing nervous system, and is rendered possible by the steady improvement in the conditions of life, particularly by the improved dietary standards. There is danger that with a rapidly developing nervous system civilised man will tend more and more to resemble a boat which is too heavily engined unless there is a corresponding development of the physique,

and to this tendency the great increase of insanity may be due. There is no necessity for the type to be over-strung, given a well-developed physique. Many of the finest examples of nervous development and nervous energy in our public life are not over-strung because their well-developed nervous systems are founded on well-developed physical frames. As the nervous system appears to direct the distribution of nutrition it would probably have first call on the supply.

In this connection may be mentioned the fact that a London journal described the Russian ballet dancers as "usually short young women." As their training develops and their performances expend a vast amount of nervous energy, it is possible that this has some effect on their physique, especially as they commence their training very young. It is a significant fact, also, that Pearson finds that tall women are more fertile than short women. Well fed and mentally active people of the towns will be relatively infertile. Well fed and sluggish country people will be relatively fertile. But in the case of the poorer townspeople the effects of greater nervous activity will, in large measure, be counteracted by bad feeding and overwork.

Of the South African Kaffirs Spencer writes: "Rich in cattle, leading easy lives, and living almost exclusively on animal food (chiefly milk, with occasional flesh), these people were then reputed to have a very high rate of multiplication. Barrow writes: 'They are said to be exceedingly prolific; that twins are almost as frequent as single births, and that it is no uncommon thing for a woman to have three at a time.'" [1]

The picture drawn by Spencer is a little too rosy. The degree of fertility will probably be chiefly decided by

[1] *Principles of Biology*, vol. ii, part vi, chap. xii.

the effect of the environment on the women of the community. One of the principal items of the Kaffir bill of fare is "mealies" or maize. All the labour of the Kaffir households, including the cultivation of the "mealie" patch, falls on the women. In the matter of food the women generally get what the men leave. They will probably seldom taste meat. Thus they are subject to considerable physical labour, combined with indifferent feeding on a diet poor in proteids. The fact that "mealies" forms a principal item in the diet of both Boers and Kaffirs is notable, since this is one of the poorest in proteids and richest in fats of all the grains. The same remark applies to rice, and rice-eating countries are more fertile than wheat- and meat-eating countries.

Contrary to what might be expected, peoples like the Boers, owning large flocks and herds, but leading isolated lives, are not generally very great meat-eaters. A farmer finds some difficulty in disposing of the carcase of an animal when freshly killed with only his own family to feed, and in such climates as that of South Africa the only way to preserve the flesh is in unpalatable forms like "biltong." On the other hand, they will obtain large quantities of "mealies," milk and eggs. It may be added that in all new countries, such as Australia, New Zealand, or America, large families are the rule in the pioneering days.

The French-Canadians are another race of whose condition Spencer draws far too rosy a picture. The truth is that these people are an ignorant and backward peasantry, leading simple, hard-working lives. "When Canada was conquered by England in 1759, it contained a French population of 65,000. Without further immigration the number had increased in 1901 to 2,400,000, including 1,600,000 in Canada, and 800,000 and their children in

the United States. Scarcely another race has multiplied as rapidly, doubling every twenty-five years. The contrast with the same race in France, where population is actually declining, is most suggestive. French Canada is, as it were, a bit of medieval France, picked out and preserved for the student of social evolution. No French Revolution broke down its old institutions, and the English conquest changed little else than the oath of allegiance. Language, customs, laws and property rights remained unaltered. The only State Church in North America is the Roman Catholic Church of Quebec, with its great wealth, its control of education, and its right to levy tithes and other church dues. With a standard of living lower than that of the Irish or Italians, and a population increasing even more rapidly, the French from Canada for a time seemed destined to displace other races in the textile mills of New England." [1]

Thus the race which is in France perhaps the least fertile in the world becomes in Canada, " with a standard of living lower than that of the Irish or Italians," one of the most fertile races in the world. They are a race of backward peasant farmers, living in a country which is under snow for some five months in the year, and earning their living by hard physical labour in which their wives, no doubt, take a substantial share. Throughout the world all races of mankind tell the same story, with one or two doubtful exceptions.

Most observers seem to agree that many of the more backward races of the world, such as the Hottentots and Bushmen of South Africa, generally have small families. Spencer quotes Barrow as writing a century ago of the Hottentots that they were poor and ill-fed, and had to do all the work for the idle Boers. He added

[1] *Races and Immigrants in America*, John R. Common.

that they seldom have more than two or three children, and that many of the women are barren. It is doubtful, however, if the Hottentots were really badly used by the Boers when working for them as servants. The case of the Bushmen was different. They lived by hunting, and when the Boers killed off the game from their hunting-grounds, they were driven to make depredations on the cattle of the Boers. This led to reprisals, and a war of extermination was waged against them. It is not probable that the Hottentots lived harder lives than the lower-class Chinese. Indeed, their lives were probably less hard. Yet it is the custom to attribute their small families to the hard conditions of life under which these lower races live.

Similar statements are made about other races. Westermarck[1] quotes Mr. Catlin as saying: "It is a very rare occurrence for an Indian woman to be 'blessed' with more than four or five children during her life; and, generally speaking, they are contented with two or three." Among these lower races there is an immense mortality especially among children. The mortality among adults is also very great owing to wars, disease, and other misfortunes. The above remarks do not appear to be based on very accurate investigations. If they are true, how have the numbers of the race been kept up in the past? No doubt the Indians are dying out now, but they must have existed for ages before the discovery of America in undiminished numbers, although continually at war.

Speaking of the Equatorial Africans, Mr. Reade says: "Propagation is a perfect struggle; polygamy becomes a law of nature; and even with the aid of this institution, so favourable to reproduction, there are fewer children than wives."[2] Consider the circumstances of the case.

[1] *The History of Human Marriage*, Westermarck. [2] *Ibid.*

Africa has been ravaged by the slave trade for centuries. Huge areas have been devastated again and again. Pestilences on a gigantic scale have swept the country. The people have been continually fighting amongst themselves. The infantile mortality rate is, of course, enormous. In spite of all these factors making for an enormous deathrate, the total numbers of the population do not diminish. Yet we are told that the number of children is less than the number of wives! Surely the age of miracles is still with us.

The generally received opinion that the lowest races are very infertile does not appear to be based on a careful examination of the birthrate. Rather it seems to be due to a superficial observation of the number of living children. Where the deathrate is very high, a high birthrate is quite compatible with small families. We have seen that various observers estimate that nine out of ten of the children born to the lower-class Chinese never grow up. This means, if true, that in order to maintain the numbers of the population an average of twenty children must be born to every two adults. Even allowing for exaggeration, it is easy to see that there may be a high birthrate and still small families. If these low races are actually infertile, it can hardly be because they lead harder lives than the lower-class Chinese; nor is it to be supposed that they are governed by different biological laws.

The Equatorial Africans live in a country with a fertile soil and a hot, moist climate—a country which produces an abundance of crops in return for a small amount of labour. Compare this with the Russian peasant woman, living in a cold and inhospitable climate, with a comparatively infertile soil. She labours in the field along with the men, and is even said to assist in drawing the plough.

Yet these Russian peasant women are the most fertile in Europe. It is probable that the day-to-day life of most of these primitive peoples is not so hard as the lives led by the poorest classes in Europe, especially in Russia. If, therefore, they are less fertile, it will be because their lives are less hard, not because the conditions of life are harder. But such evidence as is available seems to point to their being very fertile.

Take the case of the "Western Australians, among whom the mortality of children is so enormous that the greater number of them do not survive even the first month after birth, and who inhabit a land pre-eminently unproductive of animals and vegetables fitted to sustain life, a land where 'during the summer season the black man riots in comparative abundance, but during the rest of the year . . . the struggle for existence becomes very severe.'"[1] And take as a further example the inhabitants of the highly favoured country of Uganda. "One great source of mortality is the unprecedented lack of knowledge and common sense shown by the women. Children are never allowed to be born in the house, the mother being always carried out into the open air, and the first operation the child experiences is that of being washed in cold water. Then, though the country is not supplied with cow's milk, and few peasants can obtain it, they never milk the goats, of which almost every peasant has a few; and when the mother dies, or cannot produce food for her offspring, they try to bring up the child on the soft pulp of bananas, or banana beer. The wretched state of housing, too, is responsible for many deaths. No weakling can live under such conditions, and 80 per cent. or more of the children die in early infancy."[2]

[1] *The History of Human Marriage*, Westermarck.
[2] *The Baganda at Home*, C. W. Hattersley.

The Baganda are an exceptionally intelligent race occupying an exceptionally fertile country. As such races as the Bushmen, the Hottentots, and the Australians are much more depraved, and live under much harder conditions, it seems certain that their deathrate is much higher. With the aid of a little simple arithmetic the reader may form for himself a rough estimate of the number of births necessary to maintain the numbers of the population, and may judge for himself the validity of the current opinion that the lowest races are less fertile than the more civilised races. A mass of evidence to the same effect might be quoted. Apparently the facts deserve a much more painstaking and exact investigation than they have yet received.

As an example of the loose way in which superficial observations and opinions are propagated as established facts may be mentioned the belief that half-castes are very infertile. This has been shown by Westermarck to be without foundation. Bishop R. Salvado says: "With regard to the sterility of half-caste natives, of which I had no experience when I wrote my book, I am able now to deny it altogether, except in cases similar to those among Europeans. I know several cases of husband and wife, half-caste natives, having at present six and seven and even eight children, and they may in time have more; and I know a good many Europeans who, having married native women, have several children. In fact, in the case of one of these marriages there were six children and in another seven, and I could give the names of each of them." [1]

These facts are the more remarkable because Dr. J. R. Thomson says that "the Australian woman, when she places herself under the roof of a European settler as

[1] *The History of Human Marriage*, Westermarck.

his concubine or wife, appears to become less fertile, although she has more regular diet, comfort and covering."[1] She probably becomes less fertile *because* she receives better diet, comfort and clothing. The principle provides that in actual famine conditions or cases of excessive debility the birthrate will diminish. But if such conditions are very prolonged the race will become extinct.

It is in comparisons between the birthrates of different social classes of the same country that the operation of the principle will be most clearly traced. The people will live under the same climate and under much the same laws and institutions, and the statistics will be compiled by the same methods. As it is probable that the degree of fertility will be decided mainly by the effects of the environment on the women of the community, it is to the condition of the women that we must look for evidence.

Criticising another theory Spencer says: "That absolute or relative infertility is commonly caused by mental labour carried to excess is more clearly shown. Though the regimen of upper-class girls is not what it should be, yet, considering that their feeding is better than that of girls belonging to the poorer classes, while in most other respects their physical treatment is not worse, the deficiency in reproductive power among them may be reasonably attributed to the over-taxing of their brains, an over-taxing which produces a serious reaction on the physique. The diminution of reproductive power is not shown only by the frequency of absolute sterility, nor is it shown only in the early cessation of child-bearing; but it is also shown in the very frequent inability of such women to suckle their infants. In its full sense, the reproductive power means the power to bear a well-developed infant

[1] *The History of Human Marriage*, Westermarck.

and to supply that infant with the natural food for the natural period. Most of the flat-chested girls who survive their high-pressure education are incompetent to do this. Were their fertility measured by the number of children they could rear without artificial aid, they would prove relatively very infertile." [1]

The remarks about flat-chested girls and the overtaxing of their brains need not be taken too seriously. This is special pleading. Infertility is not confined to flat-chested girls of inferior physique. On the contrary, it is most conspicuous among those women who have had the advantage of good feeding and the best physical training. It is very common among women of a pronounced athletic tendency. Physical culture and bodily labour, it should be borne in mind, are very different things. The one consists of exercise in moderation, often accompanied, as in the case of games, with agreeable mental stimulus. The other consists of more or less exhausting drudgery, often depressing in its effects. The difference in nervous energy between a well-fed, athletic women and the average poorly-fed and depressed wash-woman is conspicuous.

The view that severe mental effort seriously affects the fertility of women receives strong confirmation from a statement by Dean Inge before the National Birthrate Commission. "A few years ago very careful statistics were drawn up as to the fertility of women, either both at Oxford and Cambridge or at Oxford alone—I am not quite sure which—arranging them in classes, with the remarkable result that the third-class women had more children than the second-class, and the second-class more children than the first-class. Those who had been through a severe intellectual course were sterile, and

[1] *Principles of Biology*, vol. ii, part vi, chap. xii.

those who had obtained, say, a first-class in mathematics were the most barren of all." [1]

This was certainly a remarkable result, though it is rendered very probable by the evidence already reviewed. Perhaps the fact that the Commission, in face of such evidence as this, reported themselves as unable to discover any connection between intellectual development and infertility was because they found, on examining the records of a considerable number of women who had received a college education, that they were no more infertile than a number of women who had not been educated at college. But this shows a misconception. Intellectual activity is not confined to colleges or study. A woman who is educated privately, and who leads the active everyday life of the woman of the world, may be as active intellectually and develop as much nervous energy as a college woman, or more. It is a question of the degree of mental activity, not of whether a woman receives a college education or not. Now, in the case of the women mentioned by Dean Inge who had gained honours at college it is clear that those who gained a first-class must have been of higher cerebral development than those who only gained a second-class, or else must have worked their brains more assiduously. Hence the difference in fertility.

Hawthorne, in *The Scarlet Letter*, has a passage which admirably describes the effect of a superior and intellectually stimulating environment on the physical development of women. Comparing the modern American woman with the women of the old immigrants, he says: "Morally, as well as materially, there was a coarser fibre in those wives and maidens of old English birth and breeding than in their fair descendants, separated from them by

[1] *The Declining Birthrate*, p. 328.

a series of six or seven generations; for throughout that chain of ancestry every successive mother has transmitted to her child a fainter bloom, a more delicate and briefer beauty, and a slighter physical frame, if not a character of less force and solidity than her own. The women who were now standing about the prison door stood within less than half a century of the period when the man-like Elizabeth had been the not altogether unsuitable representative of her sex. They were her countrywomen, and the beef and ale of their native land entered largely into their composition. The bright morning sun, therefore, shone on broad shoulders and well-developed busts, and on round and ruddy cheeks, that had ripened in the far-off island, and had hardly yet grown paler or thinner in the atmosphere of New England."

As education spread and the environment grew more complex and intellectually stimulating, so the nervous system developed and the physique grew less coarse. A more sensitive type developed with a larger fund of nervous energy, but less heavy in frame and muscle. No doubt the refinement of the physique is largely due to the diversion of nutrition for the purpose of maintaining the costly nervous system; but probably more subtle causes are also at work. The change is not confined to America, but is to be seen all over the world where the environment is improving. In comparisons between the women of the poorer classes and the women of the richer classes in any country the difference can be seen, and also in comparisons between countrywomen and women living in the large cities. But women of all classes are in some measure affected by the change, which, of course, is complementary to the change in the physique of men, and their increasing nervous development.

Looking at the women painted by the Old Masters of the Middle Ages the change is conspicuous. This is how Nitti describes them: "The painters of the Renaissance handed down figures of healthy and strong women; even the Madonnas were for the most part portraits of mothers with full breasts and strong bodies, with a baby on their arm or around their neck. The types of women painted by Rubens, Rembrandt, Titian, and even Raphael, are types of healthy and robust women, under whose naked bosoms runs a sound and vigorous blood." [1] Nitti then goes on to utter the usual pessimistic lamentations about the alleged decadence of the modern woman. In this it is not necessary to follow him. It is not logical to look upon the inevitable results of progressive evolution and cerebral development as the stigmata of degeneration.

A coarser type is not necessarily superior. A more sensitive type is not necessarily inferior. It is true that the more highly developed type does not reproduce as readily as the more primitive. But if reproductive capacity be accepted as the test of superiority, man is inferior to the dog or the rabbit, and almost infinitely decadent when compared with those unicellular organisms from which he is supposed to have evolved. Again, the average business man is probably less efficient than the average navvy at shovelling coal, but he is not to be looked upon as an inferior type in consequence. Take a bird's eye view of the facts as a whole: compare the big, sluggish queen bee with the small and active worker; compare the big-framed lowland sheep with the small and active mountain sheep; compare the heavy, placid cart-horse with the light-framed, highly-strung racer; or compare the heavy, large-boned, slow-thinking countrywoman with the slight-framed, highly strung woman of the

[1] *Population and the Social System*, Nitti, part ii.

educated and wealthy classes, and the facts throughout show that the development of the nervous system and nervous energy are accompanied by lessened fertility.

There is some reason to believe that the development of the nervous system as the result of the increasingly complex environment and increasing intellectual activity is being accentuated from generation to generation. "The parturitions of savage women resemble those of the lower animals in their comparative ease, the mother often resuming her duties immediately after birth. As a rule, the difficulties of civilised women are very much greater, for few of them are able to pursue their occupation for a fortnight or more after parturition. Their difficulties increase with each successive generation. At the beginning of the nineteenth century, according to the statistics of the Rotunda Hospital, instrumental aid was given to women on the average once in 608 cases. Probably it is now given twenty times as often. No doubt much of this change is due to the greater skill and confidence acquired by medical men: but certainly not all of it. Every medical man in ordinary practice sees many cases in which the woman would perish but for his aid.

"Several attempts have been made to explain this growing disproportion between the child's head and the maternal pelvis."[1] It seems a fair inference that the trouble is due to the increase in the relative size of the child's head, and that this is due to the development of the brain in response to the increasing complexity of the environment. It is certainly not due to a decrease in the width of the female pelvis among civilised races, for the pelvis of the average civilised woman is conspicu-

[1] *Principles of Heredity*, Dr. Archdall Reid, chap. xxv.

ously wider than the pelvis of the average savage woman. What are needed in this connection are systematic observations extending over a number of generations.

Such a number of authorities have confirmed the fact of the steady decline of the birthrate from the poorest to the richest classes, and such a mass of statistics have been gathered in support that it seems unnecessary to go in for an extensive discussion of this aspect of the problem. The following table by Dr. Bertillon showing the number of legitimate births per 1,000 women in Paris and Berlin is typical :—

Population in.	Births per 1,000 Married Women Aged 15 to 50.	
	Paris.	Berlin.
Very poor quarters	143	204
Poor quarters	128	198
Comfortable quarters	109	192
Very comfortable quarters	96	172
Rich quarters	94	145
Very rich quarters	85	121

Nothing could be more striking than the gradual reduction of the degree of fertility as the population grows richer. It would probably be possible to estimate the degree of fertility of any given section of a community by calculating its average income. No really satisfactory explanation of this phenomenon has ever been put forward under the accepted hypothesis. For why should a man with, say, £50 a year limit his family to perhaps five, and the man with £100 a year limit his family to four, and the man with £200 limit his family to three, and so on until we reach the vanishing point among the very rich, who in a vast proportion of cases

are content to be childless in spite of the fact that they are well able to support children, and have wealth and sometimes titles to leave them? The number of children always varies inversely with the capacity to support them, and although the theory of social capillarity has some application to the middle classes, it has no application to the very wealthy. According to that theory the smallest families should be found among the lower middle classes —among those of limited means but large ambitions, who are just getting their heads above the crowd. But these people seem to have larger families on the average than the wealthiest classes. The best test, of course, is provided by the number of completely sterile marriages, but owing to the failure of statisticians to realise this, no systematic investigation of this aspect of the question has been undertaken. Yet it does seem certain that there is a steady rise in the proportion of completely sterile marriages as the birthrate falls. In France the proportion appears to be about 20 per cent., with 25 per cent. among the wealthier classes, while we have already seen that among the abler and intellectual classes in most countries it appears to range from 25 to 33 per cent., whereas completely infertile marriages are said to be very rare among such fertile races as the Philippinos and the French-Canadians. But this matter of the percentage of completely sterile marriages should receive the most careful investigation by statisticians. For the rest it need only be said that the phenomena displayed in Paris and Berlin are common to all the countries which have been overtaken by the decline of the birthrate.

In view of the immense proportion of childless marriages in France and what has already been said about the "demographic woman," it will be useful and instructive

to quote a passage from a well-known writer showing what the attitude of French women towards children really is. Mr. W. L. George, who has an intimate knowledge of France, declares that "maternal love is a ferocious thing, ready at a pinch to devour the mother herself; in France it is carried to sublime lengths of devotion, to sublime lengths of folly. Owing, perhaps, to the fact that families are small, that they so often number but one child, the mother's love concentrates itself round but few objects; it gains in intensity that which it loses in extent. The child is everything; its well-being, its training, its education, are the mother's perpetual care. French households do not know the nursery where the child is given over to hirelings; it hardly knows the kindergarten where it is estranged from its mother, the boarding school at an early age where the gentle boy is coarsened and brutalised. Not only does the French mother usually nurse her own baby, but in later years she will attend to its feeding and clothing herself; she will herself give it its first lessons, make it her playmate as well as her toy. In these respects she does not differ from the best British mothers, but the average type seems superior to that known in these isles." [1] And yet on the accepted theory we have to assume that in something like 20 per cent. of cases these women are taking the most troublesome precautions from the very marriage eve to avoid having a single child!

From the fact that before 1870 there were 4·99 children per marriage on the average among clerical families, and after 1870 an average of 4·2, Dr. Whetham [2] infers that there has been no decline of fertility due to natural causes. Against this, however, may be set the fact that Dean Inge

[1] Quoted from *Fecundity versus Civilisation*, Adelyne More.
[2] *The Family and the Nation.*

declares that "next to the doctors and the teaching profession, the clergy are now foremost in exercising the necessary prudence."[1] A decline of nearly one-sixth is not to be ignored, and we may be confident that had the figures been arranged in decades a considerably larger fall would have been shown. A table given by Dr. Stevenson in *The Falling Birthrate* shows that their average fertility falls between that of carpenters and teachers. But should we expect, on the theory set forth in this work, as large a decline among the clergy as among the wealthy classes generally? It must be borne in mind that there has been little or no increase in the incomes of the clergy. They are comparatively poor men, leading, during the greater part of their careers, quiet lives in small country towns and villages. The women with whom they come into contact are in large proportion church workers of quiet, matronly disposition. Clergymen have few opportunities of marrying heiresses, and they obviously cannot afford to marry women of expensive tastes. In short, their wives will be usually women of quiet tastes who have spent their early years in country vicarages and similar environments. And if their fertility shows only a moderate decline, are we justified in assuming that there has been no greater decline among women who have spent their lives among the whirl of society in London, New York, or Paris? And, after all, the fertility of the clergy is only a fraction greater than that of the middle classes generally. Moreover, while the average family was only 4·99 even before 1870, at a period when it is assumed that the use of preventive measures was practically unknown, Dr. Woodruff declares that the family still numbers from fifteen to twenty among the Philippinos.[2] To

[1] *Evening Standard*, August 30, 1920.

[2] *The Expansion of Races*, p. 177.

what shall we attribute this difference, if not to a difference of natural fertility due to a difference of environment?

The theory implies that in the fluctuations of the fortunes of a race, periods of depression will show an increasing birthrate and periods of prosperity a decline. Nitti remarks of the French that this race, which has now become so sterile, "was able in less than three-quarters of a century, from 1715 to 1789, to increase from eighteen to twenty-six millions."[1] This was the period in French history of great wars, of profligate extravagance and of abominable oppression, which culminated in the French Revolution.

Nitti further says: "Generally speaking, countries which have a great mortality have also a great birthrate, and vice versa; we might almost say that death calls for life, and that there is something unconscious and fatal in the vicissitudes of things.

"Wars, famines, and epidemics are generally succeeded by years of a very high birthrate. In France in the two years preceding 1870 the birthrate was only 20·5 per 1,000, but after the very high deathrate produced by war and small-pox in 1870—1871, the birthrate rose in 1872, and for some years following remained at 26·7. In Prussia, while for two years preceding 1870 the birthrate was 39, it increased and remained at 41·5 for the three succeeding years.

"In 1868 Finland suffered from a terrible scarcity, which increased the deathrate, but a remarkable fecundity during many years filled up the gaps."[2] Wars, famines, and epidemics produce periods of hard times which show their effects in the increased birthrate. The jump in the birthrate which usually follows a war, however, seems to be largely due to the fact that the war has taken a

[1] *Population and the Social System*, Nitti. [2] *Ibid.*

large proportion of the men away from their wives and led to a general postponement of marriage. With the return of the men there is naturally an increase of both the marriage and birthrates. Europe is witnessing such a temporary rise at present, but its duration will probably be only a matter of months.

At the beginning of last century there occurred in England an enormous dislocation of the old home industries, owing to the introduction of the factory system. The effect was disastrous to the working classes, and led to a serious lowering of the standard of comfort among them. It also led to the employment of women in the factories on a large scale. The resulting effect on the birthrate is described by Nitti. "In England, as in every industrial country, the wages of the women and children supplemented the insufficient wages of the adult. Then the labouring class, impelled by necessity, abandoned that prudent foresight which it had maintained for centuries and multiplied itself without bounds and without order."[1] No evidence can be produced as to the exercise of a "prudent foresight" in previous centuries; but it seems certain that there was an immense increase in the birth-rate. Much of the apparent increase may have been statistical, and due to improved registration; but the rapid increase of population seems to show that much of it was real.

Like causes produce like effects, and a similar result is making itself apparent in Japan to-day. The rapid introduction of European and American machinery is breaking up the old home industries, and leading to the employment of a large number of the people in the factories, including, of course, a disproportionate number of women and children. This has inevitably led to a

[1] *Population and the Social System*, Nitti.

lowering of the standard of comfort. Lafcadio Hearn declares that with no legislation to protect the workers there have been brought into existence "all the horrors of the factory system at its worst."[1] The effect is to be seen in an enormous increase of the birthrate, comparable in magnitude with the corresponding phenomenon in England. Thus we are told that "in Japan the birthrate is rising, and has increased in the last twenty-five years from 25·8 to 39·9 per 1,000 of the population."[2] No doubt a good deal of this apparent increase is merely statistical, but not all of it. This is shown by the fact that with the increased prosperity brought about by the war, and probably also as the result of legislative measures to protect the workers, the birthrate has begun to decline.

One peculiarity of the advocates of the view that the decline of the birthrate is due to deliberate restrictive measures is their failure to realise that a rise in the birthrate stands in just as much need of explanation as a fall. Birthrates have risen as well as fallen in many countries at periods long before the Neo-Malthusian League was heard of. And if natural causes are capable of causing an increase, then a reversal of the conditions which brought about the increase should produce a decline. The conditions which brought about the increase in England about the beginning of last century, and in Japan towards the end of it, have now been reversed, and the decline to be anticipated has actually occurred. As the result of natural causes both increase and decrease are readily understood. But how explain the increase on the accepted theory? Nitti, who is evidently not unconscious of this dilemma, hints at a "prudent foresight" as having been practised before the increase occurred, but

[1] *Japan: An Interpretation.* Lafcadio Hearn.

[2] *Aristocracy of Birth*, R. J. Ewart. *Eugenics Review*, July, 1911.

which was abandoned as soon as the workers experienced an urgent need for it. The explanation, however, is altogether unconvincing. This assumption that the readiness of people to bear children always varies inversely with their ability to support them is an extraordinary example of the lengths to which assumption will be carried in the effort to give plausibility to untenable theories.

The birthrate continued to increase in England until the development of trade unionism, the passing of factory legislation, and the spread of education produced a general improvement in their condition. Then a decline set in, and has continued ever since. Much the same story has been repeated in all other countries which have passed through a similar industrial cycle. Here are figures showing the decline in the German birthrate: [1]—

Births per 1,000 *Inhabitants.*

1860	37·9	1905	34·0
1876	42·6	1906	34·1
1890	37·0	1907	33·2
1895	37·3	1908	33·0
1900	36·8	1909	32·0
1902	36·2	1910	30·7
1903	34·9	1911	29·5
1904	35·2	1912	29·1

As one table is typical of the rest, there is no need to multiply statistics.

Nitti [2] gives some interesting figures showing the improvement in dietary standards.

The average consumption of corn in France for every inhabitant :—

	Hectolitres.
In 1821	1·53
In 1842	1·85
In 1872	2·11
In 1888	2·70

[1] From *Fecundity versus Civilisation*, Adelyne More.

[2] *Population and the Social System.*

Articles of food consumed by the Belgian working man, calculated by months :—

	1853.	1884.	1891.
Bread, kil.	15·920	17·677	20·770
Potatoes, kil.	22·573	21·966	17·866
Meat and bacon ..	0·757	1·527	1·828
Butter and fat	0·875	1·233	1·246

The outstanding features are the increase in the consumption of bread, meat and butter, foods rich in proteids and fats, and the decrease in the consumption of the relatively innutritious potato. The consumption of meat has increased enormously in most countries, and in this connection may be noted the fact that experiments carried out by Dr. Chalmers Watson [1] indicate that a purely meat diet produces sterility "more or less complete" in animals. True, the conditions were very severe, but the experiments indicate that the great increase of meat-eating may be a contributory cause of the increasing sterility among human beings.

In the light of the facts examined we are enabled to understand the curious revenge often obtained by subject races in outbreeding and ultimately absorbing their conquerors. For example, the Saxons under the Normans, and the Chinese under the Manchus. It is true that Nitti expresses the view that slaves are unprolific, which appears to be the received opinion, but he gives no evidence in support of this view save some vague assertions that enslaved races abandon themselves to despair. It seems to be one of those conventional fallacies which pass current because no one takes the trouble to examine the facts.

There is no obvious reason why slaves should be in-

[1] *The Declining Birthrate.*

fertile. Human nature is very adaptable. No one would assert that slaves are less subject to hunger and thirst than free men. Why, then, should the sexual appetite fail? Nitti attributes this alleged infertility to despair; but he also attributes the excessive fertility of poor races and classes to the same cause. It is not clear why despair should cause excessive fertility in one case and sterility in another. The evidence all goes to prove that slaves are generally fertile. The serfs of medieval Europe and Russia must have been very fertile, as is evident from the fact that they maintained their numbers in spite of an enormous deathrate. The negroes in America and the Israelites in Egypt were also very fertile. At the period immediately preceding the fall of the Roman Empire it is asserted that nearly one-half of the population of Italy consisted of slaves, and this does not suggest infertility.

In the case of the negroes of the Northern United States the degree of fertility was much greater than among the whites in the days of slavery. After emancipation and with the general improvement in the standard of living the negro birthrate began to show the usual symptoms. "At the beginning of the nineteenth century the southern negroes were increasing much faster than the southern whites. At the end of it they were increasing only about three-fifths as fast."[1] The civil war and emancipation which brought improvement to the lot of the negro brought financial disaster to his masters. The Southern States are the poorest and most backward, and they contain large numbers of "poor whites" whose condition is little if at all better than that of the negroes. It is significant that there appears to have been as yet no serious decline in the white birthrate in the South. "We have seen

[1] *Races and Immigrants in America*, John R. Common.

that the negro population has not kept pace with the native white population. The reason is to be found in the smaller excess of births over deaths."[1] The larger deathrate of the negro appears to be due to constitutional weaknesses which make him peculiarly liable to consumption and other diseases, and also to his loose sexual habits.

A classic example of the effect of oppression on the fertility of a race is provided by the case of the Israelites in Egypt under Pharaoh. Let the chronicler tell his own story :—

"Now there arose up a new king over Egypt, which knew not Joseph.

"And he said unto his people, Behold, the people of the children of Israel are more and mightier than we :

"Come on, let us deal wisely with them ; lest they multiply, and it come to pass, that, when there falleth out any war, they join also to our enemies, and fight against us, and so get them up out of the land."

Pharaoh was a prudent and thoughtful statesman. His method of dealing with the situation was eminently statesmanlike.

"Therefore they did set over them taskmasters to afflict them with their burdens. And they built for Pharaoh treasure cities, Pithom and Raamses.

"But the more they afflicted them, the more they multiplied and grew. And they were grieved because of the children of Israel."

No wonder they were "grieved." The Israelites were notoriously a stiffnecked people. On this occasion they displayed a perversity that must have driven Pharaoh nearly to distraction. Such a swarm of little Israelites

[1] *Races and Immigrants in America*, John R. Common.

appeared as had never been known in the history of the tribe.

"And the Egyptians made the children of Israel to serve with rigour:

"And they made their lives bitter with hard bondage, in mortar and in brick, and in all manner of service in the field: all their service, wherein they made them serve, was with rigour.

"And the king of Egypt spake to the Hebrew midwives, of which the name of the one was Shiprah and the name of the other Puah:

"And he said, When ye do the office of a midwife to the Hebrew women, and see them upon the stools; if it be a son, then ye shall kill him: but if it be a daughter, then she shall live.

"But the midwives feared God, and did not as the king of Egypt commanded them, but saved the men children alive.

"And the king of Egypt called for the midwives, and said unto them, Why have ye done this thing, and have saved the men children alive?

"And the midwives said unto Pharaoh, Because the Hebrew women are not as the Egyptian women; for they are lively, and are delivered ere the midwives come in unto them."

This liveliness is noteworthy. Evidently then, as now, difficult confinements were among the privileges of the ruling classes. Those were the spacious days when every freeborn and independent Egyptian claimed the right to wallop his own Hebrew. But the effect of oppression was to make the Israelites fertile to an unprecedented degree, "and the people multiplied, and waxed very mighty." The king of Egypt was at last driven to desperate measures.

"And Pharaoh charged all his people, saying, Every son that is born ye shall cast into the river, and every daughter ye shall save alive."

How far this policy was made effective we are not informed. Pharaoh died, broken no doubt in heart and health by his failure to reverse the order of Nature. Let us deal gently with his errors. He did his best according to the statecraft of his age. The problem has baffled many a wiser and many a better man.

Of the troubles that befell his successor in his efforts to stem the rising flood of Israelitish humanity we need not here speak. Suffice to say that he at last conceived such a master stroke of policy as must have wrung a smile from the stony features of the Sphinx itself.

"And Pharaoh commanded the same day the task-masters of the people, and their officers, saying:

"Ye shall no more give the people straw to make brick, as heretofore: let them go and gather straw for themselves.

"And the tale of the bricks which they did make heretofore, ye shall lay upon them; ye shall not diminish ought thereof."

The result may be imagined! Centuries have rolled into centuries. Behind humanity lies the experience of four thousand years. Yet beneath that inscrutable calm the Sphinx must be smiling still, for statesmen are still statesmen.

Another aspect of the question which deserves some attention is presented by the seasonal fluctuations of the birthrate. Westermarck attributes these seasonal fluctuations to fluctuations of the sexual instinct due to the survival of traces of a primitive annual pairing season. But no fluctuations of the sexual instinct would affect

the birthrate unless sexual union were confined wholly to one season, assuming that there has been no decline of natural fertility. Westermarck quotes Mr. Johnston and Mr. Powers as regards the wild Indians of California and Mr. Oldfield in regard to the Watch-an-dies of Western Australia as testifying that these primitive races have an annual rutting season and only one time for copulation during the year. Yet "the he-goat and the ass in southern countries, for instance, rut throughout the whole year."[1] From this it would appear that the evolution of the lower races of mankind has advanced less far in respect to the sexual instinct than that of the he-goat and the ass.

Probably this so-called pairing season is nothing but a love feast. How is it possible to prove that sexual intercourse is confined to one part of the year? Any assertions made by the members of the tribes in question would be very liable to be misunderstood, and if understood correctly would be quite unreliable. To ascertain the fact with any degree of certainty would require observations of unheard-of delicacy—observations carried out with a nicety and thoroughness which would have brought a warm red blush to the cheek of Peeping Tom himself. Moreover, if copulation took place only at one season, all the births would take place at one season, but no such result is mentioned.

Dr. Westermarck also thinks that natural selection "can account for the periodicity of the sexual instinct in such a rude race as the Western Australians, among whom the mortality of children is so enormous that the greater number of them do not survive even the first month after birth, and who inhabit a land pre-eminently unproductive of animals and vegetables fitted to sustain human life, a land where 'during the summer season

[1] *The History of Human Marriage*, Westermarck.

the black man riots in comparative abundance, but during the rest of the year . . . the struggle for existence becomes very severe.'"[1] But as Dr. Westermarck quotes Mr. Oldfield as declaring that the annual pairing season in Western Australia takes place about the middle of spring, this would result in all the births occurring about the middle of winter, the season when the children would have least chance to survive. Therefore any attempt to account for the seasonal fluctuations of the birthrate as the result of pairing seasons and natural selection is hopeless.

To trace in the seasonal fluctuations of the birthrate the action of the principle advocated here is rendered exceptionally difficult by the complexity of the factors. Thus during the harvest season food is very abundant. It is a season of high feeding. But it is also a season of strenuous work, and it would be difficult to decide whether the high feeding or the hard work would be the most potent factor in affecting the birthrate. Still, as the winter season is undoubtedly the hardest period in most countries, it is during that season that we should expect, on this theory, the maximum number of conceptions to occur.

The amount of evidence available is limited, but such as there is tells distinctly in favour of the theory. Westermarck provides a quantity of evidence bearing on the point, the most important of which is contained in the following passage: "In the northern parts of Europe many more conceptions take place in the months of May and June, when the conditions of life are often rather hard, than in September, October, and November, when the supplies of food are comparatively plentiful. In the north-western province of Germany, as well as in Sweden,

[1] *The History of Human Marriage*, Westermarck.

the latter months are characterised by a minimum of conceptions. Among the Kaffirs, more children are conceived in November and December than in any other month, although, according to the Rev. H. T. Cousins, food is most abundant among them from March to September. And among the Bateke, the maximum of conceptions falls in December and January, although food is, as I am informed by Dr. Sims, most plentiful in the dry season, that is, from May to the end of August.

"On the other hand, the periodical increase of conceptions cannot be explained by the opposite hypothesis entertained by some physiologists, that the power of reproduction is increased by want and distress. Among the Western Australians and Californians, for instance, the 'season of love' is accompanied by a surplus of food, and in the home of the Bakongo, among whom Mr. Ingham believes most conceptions to take place in December and January, food is, according to him, most abundant precisely in these months and February." [1]

The "season of love" has no necessary connection with the maximum number of conceptions. Thus in support of the theory we have a number of fairly definite facts, and against it merely an opinion that the maximum number of conceptions among the Bakongo occurs during the season of plenty. A careful investigation would probably show clearly the action of the principle wherever the facts are sufficiently clear to justify an inference.

[1] *The History of Human Marriage*, Westermarck.

CHAPTER VII

THE PRINCIPLE AS MANIFESTED AMONG UNICELLULAR ORGANISMS

In the foregoing pages it has been from time to time observed that the principle under discussion is a law governing the union of sperm cell and ovum. We must now see why this is so, and endeavour to gain a closer insight into the nature of the principle. As the theory was deduced from the theory of evolution, and as the theory of evolution assumes the development of the higher forms of life from minute unicellular organisms, it follows that it should apply to the first beginnings of life among these minute organisms. The sperm cell and ovum are in the first instance nothing but specialised unicellular organisms, and we may be confident that they will be governed by the same general principles as the organisms from which they were originally derived. So that, although these organisms exist in enormous variety, and although they are adapted to an enormous variety of conditions, yet we should be able to trace, amid a vast complexity of facts, some faint foreshadowing of our principle.

Unfortunately, the evidence available on this part of the subject is very meagre. Nevertheless, such evidence as there is tells with remarkable force in favour of the theory. Before examining this evidence, however, it is necessary to inquire to what rules we should expect the conjugation of these unicellular organisms to conform. We have seen that the higher organisms generally, among

which sexual reproduction is the rule, have to meet two opposite sets of conditions. There is the case of an improving environment with a declining deathrate, when, if evolution is not to be self-defeating, the birthrate must diminish also. Conversely, when the deathrate increases the birthrate must increase also, or the race will become extinct. But there are conditions of exceptional hardship (usually temporary), such as famine, when an increased birthrate, instead of compensating for an increased deathrate, would merely add to the mischief. Therefore we may expect to find, and do find, that these organisms are rendered sterile both by excessively favourable and excessively unfavourable conditions. The same holds good of plants which are rendered sexually sterile both by extremely favourable and extremely unfavourable environments. So that the condition most favourable to fertility, most favourable, that is, to the union of sperm cell and ovum, occupies a middle position.

This point most favourable to fertility may be termed the optimum point for fertility. It is probable that from this point the capacity for fertilisation decreases steadily with the increase of vitality, but that when the degree of vitality is lowered beyond the optimum point for fertility the capacity for fertilisation steadily decreases with the decrease of vitality. It is, indeed, difficult to see what other arrangement is possible.

The usual method of reproduction among unicellular organisms is by division, conjugation taking place periodically. Therefore reasoning by analogy with what we have seen to be the rule among the higher organisms, we should expect that there will be an optimum point for conjugation—that conjugation will become more and more imperative with these lowly organisms as exhaustion approaches; but that when exhaustion is carried beyond a certain point conjugation will become gradually

less possible. The point most favourable for fertility will occupy a middle position.

"At the very threshold of sex difference we find that a little active cell or spore, unable to develop of itself, unites in fatigue with a larger more quiescent individual."[1] This provides a strong suggestion that the sperm cell is as much affected in its power of fertilisation by external conditions as the ovum in its receptivity, and if this is so it is probable that the declining birthrate will be almost as much due to the effect of the environment upon the men as upon the women of the community. The sperm cell will probably be governed by the same laws as the ovum in this respect. It must unite with the ovum as exhaustion approaches or perish. So the fact quoted is of considerable significance, especially in the case of these but partially specialised organisms.

Certain observations by Maupas on the conjugation and division of unicellular organisms have become classical. "In November 1885 M. Maupas isolated an infusorian (*Stylonichia pustulata*) and observed its generations till March 1886. By that time there had been two hundred and fifteen generations produced by ordinary division, and since these lowly organisms do not conjugate with near relations, there had, of course, been no sexual union.

"What was the result? At the date referred to the family was observed to have exhausted itself. The members, though not exactly old, were being born old. The asexual division came to a standstill, and the powers of nutrition were also lost.

"Meanwhile, however, several of the individuals before the generations had exhausted themselves had been removed to another basin, where they conjugated with unrelated forms of the same species. One of these was again isolated and watched for five months. The

[1] *Evolution of Sex*, Geddes and Thomson, chap. ii.

usual number of successive generations occurred; members removed at different stages were again observed to conjugate successfully with unrelated forms, and this was done to the one hundred and thirtieth generation. After that, however, the family being again near its end, the removal was no longer any use. About the one hundred and eighteenth generation the strange sight was seen of individuals of the same family attempting to unite with one another. The results were, however, nil, and the conjugates did not even recover from the effects of their forlorn hope."[1]

Here we have just such facts as the theory would lead us to expect. When the cells are fresh and in full vigour, conjugation is unnecessary. As they become exhausted during repeated asexual generations, conjugation becomes more and more necessary up to a certain point. When, however, exhaustion is carried beyond that point, conjugation becomes impossible even with unrelated forms. But whether the exhaustion which comes of repeated asexual generations is analogous with the results of overwork or under-feeding among the higher organisms is a debatable question. It has been termed "senile decay."

The effects of nutritive conditions among these lower organisms parallel in a singular way what we have seen to be the rule among the higher forms of life. "Thus, if nourishment be continually and abundantly supplied to cultures of Ciliata, pairing can be prevented (Maupas). They continue to divide until the whole culture dies off in consequence of senile degeneration. On the other hand, cultures of Infusoria which are approaching sexual maturity may be induced to pair by withholding nourishment."[2] This is closely analogous with what occurs among the higher forms of life. Surely, therefore, it

[1] *Evolution of Sex*, Geddes and Thomson, chap. xii.

[2] *The Cell*, Dr. O. Hertwig.

requires no great stretch of imagination to infer that the sperm cell and ovum are governed by the same biological laws as the organisms from which they were originally derived. Although we are not expressly so informed, yet it seems fairly obvious that if starvation were carried beyond a certain stage conjugation would become impossible, since the organisms would enter into a dying condition. It might have been expected that the exhaustion resulting from repeated asexual divisions would have ultimately overcome the effects of high feeding, and have rendered conjugation possible. But possibly the term "senile decay" is justified and the effects of too prolonged asexual reproduction analogous with the effects of old age in the higher organisms rather than with the effects of fatigue or under-feeding.

The experiments of Maupas were not quite complete. Subsequent observations have shown that asexual division can continue indefinitely among these lowly organisms if the culture mediums in which they live are kept quite pure or constantly changed. This has been demonstrated by several experimenters, and L. L. Woodruff has carried cultures of Paramæcium through two thousand generations, extending over three and a half years. Woodruff concludes that these organisms excrete products which are poisonous to themselves, and that so long as the infusions in which the organisms live are kept perfectly free from these excretions, there is no reason why they should not continue to divide indefinitely. But a small addition of the products of excretion renders conjugation necessary, or produces the symptoms of "senile decay." If senile decay among the higher animals be looked upon as due to the imperfect elimination of waste products, there may be some analogy between the two cases. But the net result of these experiments is that so long as the conditions are such as to keep the organisms in full health

and vigour conjugation is unnecessary; but when conditions become adverse to the vitality of the organisms and exhausting, they must either conjugate or perish. Thus the parallel between the higher organisms and the unicellulars is quite close.

The principle of the vital optimum is clearly manifested by these unicellular organisms. "The action of heat may be two-fold: up to a certain point it quickens development and the general life, favouring asexual reproduction and parthenogenesis rather than the sexual process; beyond that limit of comfortable warmth, so variable for different animals, it may induce a feverish habit of body and hasten reproductive maturity and sexual reproduction. In other words, heat may in some cases favour anabolism, in others katabolism. It is intelligible enough to find increased heat sometimes associated with increased asexual reproduction, sometimes with increased sexuality. Instances of both may be gathered from Sempers' *Animal Life*, the classical work on the influence of environment upon the organism."[1] These remarks summarise the facts in regard to both multicellular and unicellular organisms. As each type of organism will be adapted to a certain range of temperature, it is an obvious inference that any change in either direction will be "sometimes associated with increased asexual reproduction, sometimes with accelerated sexuality," according to whether it is stimulating or exhausting, this depending on its relation to the temperature to which the organisms are adapted. Another point to remember is that the optimum point, whether for vitality or fertility, is not absolutely fixed but variable, so that change is often beneficial to the organism.

"Finally, mature animal egg cells, even when under normal conditions in the ovary or in the oviducts, live

[1] *Evolution of Sex*, Geddes and Thomson, chap. xvii.

only for a short time; they soon become over-mature. (Hertwig, vol. vi. p. 32). Their normal functions become weakened, as is seen from the fact that, although they can still undergo fertilisation for a time, yet this occurs in an abnormal fashion; several spermatozoa make their way into the egg, the result being an abnormal process of development. Without doubt, this phenomenon is analogous to the senile degeneration of Ciliata which have been prevented from pairing at a suitable period." [1] We see again that there is an optimum point for fertilisation, but there seems no reason to suppose that there is any analogy between the effects of over-maturity and the effects of fatigue or lack of nourishment.

Other similar facts are reported by Hertwig. "The receptive capacity of the large female gamete of the species *Cutleria*, after it has come to rest, and has become capable of functioning as an egg, lasts only for a comparatively short time. Falkenberg (vol. vii. p. 10) has performed a large number of experiments which show that, whilst on the third day after they have come to rest almost all the eggs are capable of becoming fertilised, on the fourth day only half are in that condition. Further, after this period all the eggs lose their receptive capacity, and although spermatozoids are placed in their neighbourhood, commence to die off, exhibiting the same changes as those eggs which where completely shut off from the fertilising cells." [2] This is probably what happens in the case of the higher forms of life when the eggs become over-mature.

Although the evidence showing the operation of the principle among these lowest forms of lives is relatively small in quantity, yet it tells in favour of the hypothesis with remarkable force. The facts are just what might be anticipated, and are precisely parallel with what occurs among the higher forms of life. Highly favourable

[1] *The Cell*, Dr. O. Hertwig. [2] *Ibid.*

conditions facilitate asexual reproduction, but are inimical to conjugation. Unfavourable conditions which exhaust the vitality of the organism facilitate conjugation and sexual reproduction until carried beyond a certain point, when conjugation becomes increasingly difficult. On the evolutional theory we must expect the higher organisms to be governed by the same biological laws as the primitive forms from which they were originally derived. And the evidence that such is the case is overwhelming. Therefore it becomes a question of the method by which the principle is applied among the higher organisms. It is only as a law governing the union of sperm cell and ovum that the principle can apply to all forms of sexual reproduction, from the most primitive unicellular organisms, through all grades of plants and animals up to man. No special physiological adaptation connected with ovulation or any other of the sequence of reproductive phenomena would suffice to meet all the various methods of fertilisation throughout the plant and animal kingdoms.

On the other hand, the sperm cell and ovum, being merely specialised unicellular organisms, will, we may be confident, be governed by the same laws as the primitive cells from which they were derived, and these laws, as we have seen, actually produce the same results as those manifested in the plant and animal kingdoms. It is necessary, therefore, to assume that the condition of the ovum at the time of ovulation reflects the condition of the organism as a whole. But this can only be affected through the agency of the nervous system, or, in the case of plants, the hypothetical factor which we must assume to take the place of the nervous system in animals. The nervous force is probably analogous in character with that which animates living cells, even though these possess no nervous system, as it is pre-eminently the life force. It can and does influence every cell through-

out the body of the organism, and there is no obvious reason why the reproductive cells should be exempt from its influence. The distribution of nutrition to the various parts of the body appears to be governed by the nervous system. Therefore the nervous system should determine the nutritive condition of the ovum.

There is considerable variation in the receptive capacity of the egg cells of a given individual, as experiments by Hertwig and others have shown. There would certainly also be great variation in the average receptive capacity of the egg cells of different individuals when exposed to the same conditions. It is also a well established fact that there is great variation in the penetrating powers of the sperm cells as between different individuals, for many stud animals are conspicuously good stock getters as compared with others. Thus there is provision for an enormous range of variation in individual cases. We might have the case of a male whose sperm cells were exceptionally penetrating matched with a female whose egg cells were exceptionally receptive. Or we might have the case of a male whose sperm cells were deficient in penetrating power matched with a female whose egg cells were exceptionally unreceptive. If these two couples were exposed to the same conditions, one couple would prove exceptionally fertile as compared with the other. We can thus understand how it is that, while the birthrate steadily declines with the increase of wealth and education, yet individual rich families are sometimes very fertile, and why poor people are sometimes childless or have very few children. We can also understand why some animals breed freely in captivity, whilst other individuals of the same variety are sterile. But when statistics are compiled for large classes the law of averages levels up these individual variations and shows clearly the operation of the principle.

CHAPTER VIII

ASEXUAL GENESIS AND OVULATION

HAVING shown why the principle is a law governing the union of sperm cell and ovum, it will now be desirable to examine the relation between sexual and asexual reproduction. The reasons why the principle does not apply to the latter are, briefly, that the two forms of reproduction are suitable for very different conditions of life, and react in diametrically opposite manner to the same conditions. We have seen that it is a necessary condition of the successful maintenance of any species that its reproductive capacity should bear an inverse ratio to its survival-capacity under the environment in which it lives. That is to say, the birthrate must be sufficient to compensate for the deathrate. Now, asexual reproduction accomplishes this efficiently enough, but by a different method to the sexual form of genesis. It is a method suitable for those forms of life which enjoy periods highly favourable alternating with extremely unfavourable periods.

The peculiar functions of these lower forms of life in the evolutionary scheme are best secured by the power to multiply with extraordinary rapidity when circumstances are favourable and opportunity offers, as during unfavourable periods they are either swept out of existence altogether or reproduction is entirely stopped, as, for instance, with plants and insects in winter. Those species which generally reproduce by the asexual method are

usually such as "enjoy from time to time very favourable conditions, which they can make use of for very prolific reproduction, and then pass into very dangerous and unfavourable conditions, which they survive in the shape of fertilized and hard-shelled eggs." [1]

Unicellular organisms are not only the source from which the higher forms of life are derived, but, together with the lower forms of multicellular organisms, they form the ultimate source of the food supply of the higher species. In order that this may be it is necessary that they should be able to multiply with extraordinary rapidity when circumstances are favourable. This is rendered possible by the asexual methods of reproduction.

Sexual reproduction is essentially a regulating factor. It becomes the exclusive method of reproduction among the higher animals among whom unregulated multiplication would be disastrous, and among the lower forms of life it appears when conditions become unfavourable to very rapid multiplication. Aphides or plant lice provide an excellent illustration of the relations between the two forms of reproduction. "Details in regard to these plant lice which multiply so rapidly upon our rose-bushes, fruit-trees and the like, differ somewhat in the various species, but the general facts are recognised to be as follows: During the summer months the aphides produce parthenogenetically generation after generation of females. The advent of autumn, however, with its attendant cold and scarcity of food, brings about the birth of males and the consequent recurrence of strictly sexual reproduction. In the artificial environment of a greenhouse, equivalent to a perpetual summer of warmth and abundant food, the parthenogenetic succession of females has been experimentally observed for four years; it seems, in fact, to continue until lowering of the temperature and diminu-

[1] *Darwinism and the Problems of Life*, Guenther.

tion of the food at once reintroduce males and sexual reproduction." [1]

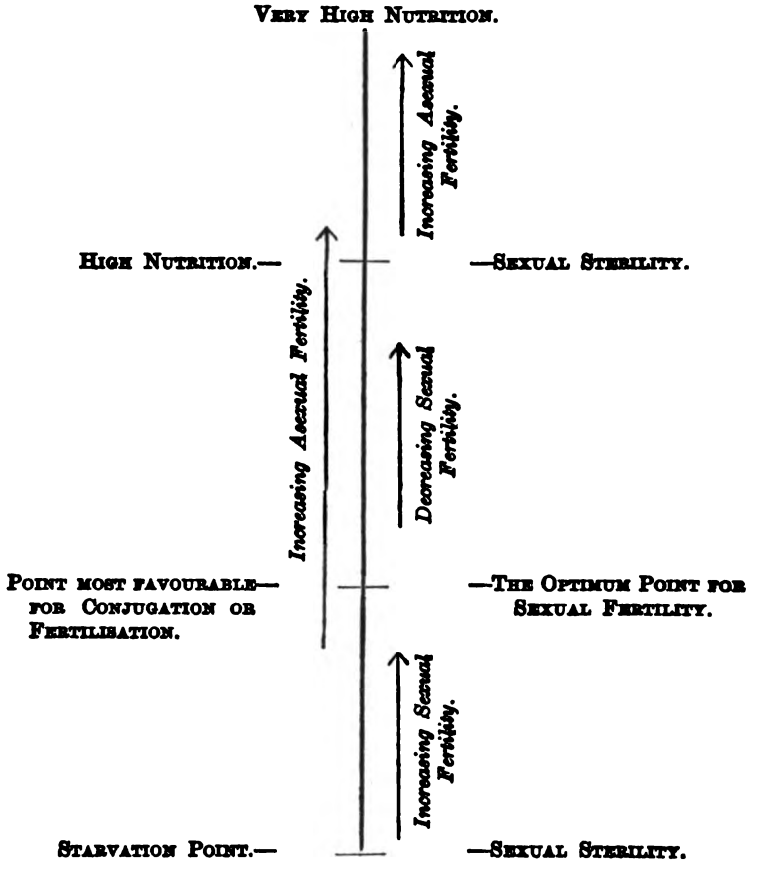
It is impossible to cover these facts by a single formula, as Herbert Spencer tried to do, assuming that the two forms of reproduction react in the same manner to the same conditions. As a matter of fact, they appear in most cases under diametrically opposite conditions. Spencer has himself admitted that it is impolitic to dung the roots of fruit-trees while the growth of sexless axes is still abundant, this growth being merely a form of asexual reproduction, and a sign that the tree is in too high a state of nutrition to produce fruit; whilst Darwin mentions that in order to make European vegetables in India yield seed, it is necessary to take them up and cut or mutilate their tap-roots, obviously for the purpose of checking nutrition.

The term "discontinuous growth" has little application to sexual reproduction, but it may fairly be applied to the asexual process. "The common hydra, in abundant nutritive conditions, produces numerous buds, and even these sometimes begin themselves to produce another generation. In other words, we may almost say, with plenty of food the polype *grows* abundantly, so obviously is this asexual reproduction continuous with growth. A check to the nutritive conditions, however, brings on the development of the sexual organs and the occurrence of sexual reproduction. In planarian worms . . . Zacharias observed that favourable nutritive conditions were associated with the formation of asexual chains, while a check to the nutrition brought about both the separation and sexual maturity of the links. Bywosch corroborates this, noting in *Microstomum lineare* that the generative organs do not become completely matured till the individuals cease to be links in a chain, and that

[1] *Evolution of Sex*, Geddes and Thomson, chap. iv.

the sexuality is hastened by outside influences such as checked nutrition."[1] Generally speaking, the degree of asexual fertility seems to be directly proportional to the degree of vitality, and the optimum point for vitality seems to be identical with the optimum point for asexual fertility.

The following diagram will give a very clear idea of the relation between the two forms of reproduction :—



The centre line represents a scale of nutrition from starvation point up to extremely favourable conditions. Under actual starvation conditions there can, of course,

[1] *Evolution of Sex*, chap. xvi.

be no reproduction. From this point upwards sexual reproduction becomes more and more possible as conditions improve up to a certain point, the optimum or best point for fertility. After that point has been passed, sexual reproduction becomes less and less possible as vitality expands under the influence of increasingly favourable conditions, until complete sexual sterility is produced. But the conditions which are inimical to sexual reproduction are favourable to the asexual process, and as conditions become steadily less favourable to the former, they become steadily more favourable to the latter.

Taking the line from the other end we see that extremely favourable nutritive conditions cause sexual sterility, but favour the asexual method of reproduction, as in a fruit-tree which is sterile sexually and bears no fruit owing to the fact that it is running to shoots and foliage through being too heavily manured. But the check to nutrition decreases the amount of asexual reproduction and renders the sexual process and the production of fruit possible. The degree of sexual fertility increases and the degree of asexual fertility decreases until the optimum point for sexual fertility is reached. After that both sexual and asexual fertility diminish until starvation point is reached. Of course, there is no clean-cut division in the nutritive scale where one process ends and the other begins. The two processes may often be seen going on together. But that in no way affects the general principle.

The two methods of reproduction are parts of a coherent scheme, and, apart from instinct as a regulating factor, the above diagram illustrates the whole plan of the reaction of the degree of fertility to the action of the environment. The asexual process is the predominant method of reproduction among the lower forms of life, being eminently adapted to the peculiar conditions of their environment, and enabling them to multiply with

extraordinary rapidity when conditions are favourable. They thus form the ultimate source of the food supply of the higher organisms, and the basis of the whole scheme of organic evolution. Sexual genesis is a regulating form of reproduction suitable for the higher organisms. As we glance along the ascending scale of life we see that it gradually supersedes asexual genesis and becomes the exclusive method of reproduction among the higher animals and man. The above diagram can be applied to the higher animals by simply following Nature and obliterating the part which deals with asexual reproduction.

The term "nutrition" is used in a very broad sense. It must not be understood as applying merely to the quantity of food. Among simple organisms the reactions to the environment will be correspondingly simple, and survival-capacity will be decided mainly by a few simple factors, the quantity and quality of the food and the temperature. But as the organism grows more complex in adaptation to an increasingly complex environment, the reactions will obviously become more complex also. And the term "nutritive conditions" in the case of the higher organisms must be taken to embrace all those varied and subtle factors which affect vitality and which are summarised by the nervous system. From the diagram we may perceive that the optimum point for fertility and the optimum point for vitality are very different things, and they may vary from practical identity to extreme divergence in different varieties, or even between different individuals of the same variety. Thus there is opportunity for an enormous range of variation between varieties and individuals even when exposed to the same environment.

Whilst discussing asexual reproduction we may conveniently inquire what are the laws which govern ovula-

tion. For ovulation appears to be analogous with asexual reproduction. In the case of parthenogenesis ovulation may be said to be identical with asexual reproduction. It might appear, therefore, that ovulation will be governed by the same laws, and that highly favourable nutritive conditions will lead to the production of a correspondingly large number of egg cells. A number of facts can be quoted in favour of this view. Thus we are told that the queen bee produces from twice to four times her own weight of eggs daily when in full laying activity,[1] and during this time she is very highly fed. Some worker wasps, during the favourable conditions of autumn, when food is very abundant, lay unfertilised eggs which produce males. And in most cases where there is a change from parthenogenesis to sexual genesis during unfavourable conditions the number of fertilised eggs is considerably smaller than those produced parthenogenetically. Flowers seem to produce an abundance of pollen in favourable seasons. These facts appear to imply that ovulation must be looked upon as analogous with asexual reproduction, and that fewer egg cells will be produced under unfavourable conditions, and more when conditions improve.

But it is not wise to press analogies too far, and there is another point of view. It may be plausibly argued that failure of ovulation or atrophy of the ovaries, as in the worker bee, is the logical development of complete sterility, and that ovulation should logically be governed by the same law as that which regulates the union of sperm cell and ovum, since ovulation, except in the case of parthenogenesis, is merely the preliminary to fertilisation. Various facts may be cited in favour of this view also.

Thus we must take flowering and the production of egg cells among plants to be analogous with ovulation among animals. Now, under excessively high nutritive

[1] *Bees and Beekeeping*, Cheshire, vol. i, chap. vi.

conditions plants not only fail to produce fertile seed, but sometimes they also fail to flower, as the extract from Darwin given in a previous chapter shows. There is also the case of the worker bee, which might, however, be reasonably quoted in favour of the opposite view that failure of ovulation is produced by unfavourable conditions, since the diet of the worker is much sparser and plainer than that of the queen. In the case of the domestic fowl, not only are the eggs less fertile when the birds get insufficient exercise, but fewer eggs are laid, and this seems to mean that fewer egg cells are produced at ovulation. Some fowl-keepers assert, however, that it is impossible to feed laying hens too highly provided that they receive plenty of exercise, and failure of ovulation in the case of individuals receiving insufficient exercise may be the result of unhealthy conditions.

In the case of wild animals in captivity which produce smaller litters, this might be due either to fewer egg cells being produced at ovulation or to fewer being fertilised. It might also be urged that if ovulation is more prolific under favourable conditions while fertilisation is more difficult, the two principles would in large measure cancel each other. Thus, as egg cells vary in receptivity, a decrease in the average receptivity might be compensated by an increase in the number of egg cells, which would increase the chances of fertilisation. But this could only compensate a decreased receptivity to a small extent.

While the weight of evidence and of probability seems to favour the view that ovulation is merely a specialised form of asexual reproduction, yet it will be best to leave this an open question. It is not one which can be settled by deduction or analogy, and the amount of evidence at present available is not sufficient to justify a decision. Possibly the solution will be found in the application of the principle of the vital optimum to ovulation.

CHAPTER IX

SOME POSSIBLE CRITICISMS ANTICIPATED

It is not improbable that the nervous charge is more intense during childhood than at any subsequent period of life. The period of growth is a period of intense metabolism. The whole system is tremendously active, and the nervous system seems to share this activity. Moreover, the bulk of the nervous system is proportionately greater, as compared with the rest of the organism, than at any later period. Nothing is so difficult for a child as to sit still. Its nerves seem to be all atingle with energy which demands an outlet. True the child may be easily tired, but children have little muscular strength, and it is a characteristic of nervous energy that it can be rapidly expended. Indeed, it is doubtful if we are justified in saying that children are easily tired. The seemingly exhaustless energy which some children display in racing about all day is amazing. I have seen children in the tropics tearing around aboard ship under conditions which left the grown up people with only enough energy to sit about in deck-chairs and gasp.

It is probable, then, that the nervous charge is most intense during childhood, and steadily declines throughout life. The most fertile period, between fifteen and thirty, occupies a middle position. Still, as the reproductive functions do not develop until towards the end of the period of growth, the intensity of the nervous charge

during childhood is not of great importance to the theory.

But if the degree of potential fertility rises as the intensity of the nervous charge falls, how is it that the most fertile period is between fifteen and thirty, instead of later in life when vitality begins to wane? Take the case of a highly fed, intellectual, and infertile member of the wealthy classes. If a high development of nervous energy leads to infertility during what should be the most fertile period, why is not this infertility overcome in later life by the decline of nervous energy due to advancing years? Perhaps unicellular organisms will throw some light on the matter. Hertwig points out that "if nourishment be continually and abundantly supplied to Ciliata, pairing can be prevented (Maupas, vol. ii. p. 30). They continue to divide until the whole culture dies off in consequence of senile degeneration."[1] The cases are singularly parallel. Yet, after all, this parallelism might be reasonably expected on the evolutional theory. It is not wise to attach too much importance to analogies, or too much weight to the absence of analogies, since Nature does not hesitate so to combine her principles in adaptation to special circumstances that they frequently become almost unrecognisable. But an analogy so precise where we might reasonably expect an analogy cannot be held as of no significance.

First of all, we see that these unicellular organisms can be prevented from conjugating by extremely favourable nutritive conditions. We should have expected that the advance of senile decay would have overcome the effects of favourable conditions and rendered conjugation possible. But this is not the case. The multicellular organisms appear to react in an exactly analogous

[1] *The Cell*, Dr. O. Hertwig.

manner. Highly favourable conditions lead to sterility. We should have expected that the decline of vitality due to advancing age would have overcome the effects of favourable conditions, and that the later periods of life would have been most fertile. But again this is not the case. Perhaps there is a genuine analogy between senile decay among the higher organisms and the phenomena which have received the same name among unicellular organisms.

Senile decay, then, and the exhaustion which results from unfavourable conditions, may be looked upon as representing two distinct principles. While the latter favours conjugation, the former is inimical. Therefore, in the multicellular organism any tendency to increased fertility due to the exhaustion of the nervous charge as the result of advancing age would be counteracted by the opposing principle of senile decay. The exhaustion in this case would, in fact, be directly due to senile decay, and so would be more than counteracted by it.

Spencer, in his *Principles of Biology*, directs some criticisms against the theory of Doubleday, that a plethoric condition of the organism is unfavourable to fertility, and that a deplethoric condition is favourable. This is a very different theory to the one outlined in these pages, in which food is only one factor and not necessarily the most important. Indeed, we have seen good reason to believe that cerebral development and mental activity are far more important than the supply of food. But as similar criticisms may be directed against this theory, it may be well to anticipate them.

Spencer says: "It may be readily shown that such an arrangement would be the reverse of self-adjusting. Suppose a species too numerous for its food to be in the resulting deplethoric state. It will, according to Mr.

Doubleday, become unusually fertile, and the next generation will be more numerous rather than less numerous. . . .

"Thus there will go on an ever increasing rate of multiplication, and an ever decreasing share of food for each person, until the species disappears. Suppose, on the other hand, the members of a species to be in an unusually plethoric state. Their rate of multiplication, ordinarily sufficient to maintain their numbers, will become insufficient to maintain their numbers. In the next generation, therefore, there will be fewer to eat the already abundant food which, becoming relatively still more abundant, will render the fewer members of the species more plethoric and still less fertile than their parents. And the actions and reactions continuing, the species will presently die out from absolute barrenness." [1]

This criticism shows a failure to grasp the most essential aspects of the problem. Take the case of wild animals. The food supply is dependent mainly on the seasons. A bad season would lead to a heavy deathrate. In the case of the larger species this would produce a higher degree of fertility; but the births resulting would in most cases fall during the next season, thus compensating in some measure for the heavy deathrate of the previous year. There would, of course, be no accumulation of food; but the next season might be a very favourable one. In the case of a very favourable season with a reduced deathrate, this would lead to a reduced birthrate next year. The principle provides for the case of absolute famine.

It is in the case of the higher animals that the principle will be of most importance. The higher we ascend in the scale of life, the more important the principle becomes, since slow-breeding animals have a much smaller margin between maintaining the species and extinction. In the

[1] *Principles of Biology*, Spencer, vol. ii, part vi.

case of small, rapidly breeding species, which rear several hatches of young yearly, the principle is traceable, as we have seen, with individuals in confinement; but in this case instinct will play the most important part, determining how many batches of young shall be reared annually. They will rear fewer batches when food is scarce and a larger number when food is plentiful. These free-breeding types are able to recuperate their numbers with extreme rapidity when circumstances again become favourable after a bad season. They thus occupy a middle position between those lowly types for which asexual reproduction in enormous numbers when circumstances are favourable is best, and those higher types whose interests are best served by a regulated sexual reproduction.

In the case of man, Spencer's remarks bear a remote resemblance to what actually does happen. Generally speaking, the supply of food in human society depends on the number of individuals who work to produce it. When the population rises or falls, the food supply, other things equal, rises or falls also. But as, on the theory set forth here, the amount of food is only one of the factors which affect fertility, a well-fed population may be highly fertile, or an indifferently fed population only moderately fertile, fertility depending not merely upon the quantity of food, but upon the effects of the environment as a whole.

Spencer's suggestions appear to have been in some measure realised when the factory system was first introduced into England. The lower standard of living led to an increased birthrate. The workers were compelled to send their children into the factories in order to supplement the earnings of the family The employers used these children to lower wages still more. The result was

that the birthrate continued to increase until the workers learned to protect themselves by combined action, and factory laws were passed to improve their conditions of employment. A similar phenomenon appeared in Japan recently under similar conditions, though the increased prosperity caused by the war appears now to be producing a declining birthrate. Any general principle, no matter how advantageous to a species as a general rule and on the whole, may act with disastrous effect under some unfortunate conjunction of circumstances.

If we glance along the ascending scale of life from unicellular organisms up to man, we note a gradual and continuous modification in the relative importance of the principles which regulate fertility. Among the lowest types asexual reproduction plays the chief part, enabling them to increase with enormous rapidity when circumstances are favourable, thus forming the ultimate source of the food supply of the higher organisms and the basis of the whole evolutionary scheme. Among the lower types of sexually reproducing animals, although the operation of the principle can be clearly traced, instinct plays the greatest part. It is instinctive reactions to external circumstances which will determine the number of batches of young to be reared annually. Reactions between each species and its enemies will also assist the mutual adjustment of numbers. In the case of the higher animals instinct plays a smaller part and the principle under discussion a much larger part. It is in human society that the principle reaches its full development, where instinct has ceased to constitute a serious regulating factor, and where reason has not yet supplied its place.

It has been suggested to me that if the fall in the birthrate is the result of a natural law which regulates

the degree of fertility to suit the deathrate, then the decline "cannot possibly be a source of anxiety." Unfortunately, this optimism is unjustified, and is the result of a failure to grasp clearly the essential factors of the problem. There is a limit to the fall in the deathrate. Even when the deathrate is reduced to the lowest possible level, people will continue to die of old age. Now, the author of the phrase quoted above seems to have been under the impression that when the deathrate ceases to fall, the birthrate will cease to fall also. There is no justification for such a belief.

The theory set forth in this work is not that the fall in the birthrate is caused by the fall in the deathrate, but that it is produced by the *same combination of causes* which produces a falling deathrate. Thus, if Mr. Brown dies of fever, consumption, or other ailments, this will in no way affect the fertility of Mrs. Jones. But the combination of causes or the environment which produces a considerable number of deaths from these ailments may very powerfully affect Mrs. Jones's fertility. And when the deathrate is reduced to its lowest possible term, the environment will not cease to affect the birthrate. An accentuation of the causes which have produced a low birthrate in the past will reduce it still further. For no limit can be set to the decline of fertility short of absolute barrenness. That is why the problem of the declining birthrate must be grappled with, lest it result in ultimate depopulation, or the replacement of our population by lower races, as happened in Ancient Rome and Greece.

CHAPTER X

MALTHUS

THE theory of Malthus has been the cause of a vast amount of confused and unnecessary argument. Let us take first the famous progressions. Malthus assumed that the potential rate of increase of the population is geometrical, and that the rate of increase of the food supply can only be arithmetrical. The *potential* rate of increase of the population is undoubtedly geometrical, apart from the principle outlined in the foregoing pages. Malthus knew of no checks upon the birthrate except such as are purely incidental. He knew nothing of a regulating principle which causes deathrate and birthrate to rise and fall together. We have seen that the potential fertility of a married woman who lives a normal length of life may be put at about thirty children at a moderate estimate. This number has often been exceeded, while among very fertile races twenty in a family is by no means uncommon.

Now, if this potential fertility were actually realised, and if the children all lived a normal length of life, in their turn realising to the full their potential fertility, the result would be a devastating flood of humanity which would sweep the earth from end to end like a swarm of locusts. The *potential* geometrical rate of increase, therefore, given a fully realised birthrate and a nominal deathrate, is indisputable.

But the necessarily arithmetrical ratio of increase of

the food supply is an assumption with less basis in fact. Food is produced by the labour of the population. Hands will increase in the same geometrical progression as mouths, and there will be a corresponding increase of the food supply until the resources of the country are taxed to the utmost. After that there will be a comparatively abrupt cessation of the increase of the food supply.

We may state the case thus: If the potential geometrical rate of increase of the population were actually realised, the food supply would, other things equal, increase in an approximately direct ratio with the increase of population until the natural resources of the country were taxed to the utmost; the increase in the amount of food would then cease. Other things, of course, are not equal. Organisation, invention, scientific discoveries and foreign commerce would modify the progress of events, and would for a time lead to an increase of the food supply greater than the increase of population. But as the resources of any country are limited, these factors would only postpone the ultimate result, for in an amazingly short time there would not even be standing room.

Malthus, knowing nothing of the principle outlined in the preceding pages, said to social reformers: The evils which you deplore are necessary for the purpose of keeping down the numbers of the population. If you improve the condition of the mass of the people, you will cause a fall in the deathrate. The fall in the deathrate will be proportionate to the degree of improvement which you effect in the condition of the people. Therefore the closer you approximate to an ideal state of society, the lower will be the deathrate, and consequently the more rapid will be the increase of population. The geometrical rate of increase will be realised in exact proportion to your success in improving conditions. As

the resources of any country, and even of the world, are limited, it follows that the increase of population must rapidly exceed these resources unless you can keep down the birthrate. Unless you can do this your efforts for social progress will be self-defeating.

The only suggestion put forward by Malthus as to the means of keeping down the birthrate was that the mass of the people should abstain from sexual intercourse, leaving that as a privilege for the rich. If this proposal aroused no enthusiasm among social reformers, it was probably because they felt, and probably Malthus felt too, that

> You may as well forbid the mountain pines
> To wag their high tops, and to make no noise
> When they are fretted with the gusts of heaven.

Malthus was perfectly sound in his logic reasoning from the facts as known to him. When he wrote the theory of evolution was merely in embryo and not a serious intellectual factor. But his logic, perfectly sound so far as it goes, is rendered futile by the one small factor which he had overlooked, the law by which Nature had provided for the difficulty. But for this Malthus would have been perfectly right, and social evolution would have been self-defeating.

This would also have been true of evolution in general. For it is an obvious deduction from the theory of evolution that to produce a superior type a superior environment is necessary, since a type must necessarily be adapted to its environment. It is impossible to have an improved environment without a reduced deathrate, for the conditions of an improved environment are those which increase the survival-capacity of the organism. But it is obviously impossible to have a reduced deathrate in

the long run without a reduced birthrate, as this would lead to rapid over-population, and bring back all the evils which are attendant upon a severe struggle for existence. Thus we see that both organic evolution in general and social evolution in particular must be accompanied by a reduced deathrate and a reduced birthrate, otherwise they will be self-defeating.

To Malthus it is sufficient to reply that there has been a vast evolution in the past, both organic evolution and social evolution, during which the condition of mankind has improved enormously. Evolution, therefore, cannot be self-defeating. This progressive evolution, moreover, from unicellular organisms upwards, has always been accompanied by a reduced deathrate and a reduced birthrate. From this it is a fair inference that such will continue to be the case in the future—that Nature will continue in the future, as in the past, to show herself far wiser than her interpreters. The idea of Malthus that the evils from which society suffers are necessary to keep down the numbers of the population is the reverse of the truth, and these evils are themselves the cause of a high birthrate.

CHAPTER XI

SPENCER

One of the most noteworthy attempts to construct an adequate theory of fertility and population was the hypothesis put forward by Herbert Spencer to the effect that the degree of fertility varies inversely with the cost of individuation. It cannot, however, be accepted as an adequate expression of the facts. In the first place, Spencer made no distinction between the variation in the inherited potential degree of fertility as between species and species and the variation in the actual degree of fertility of given individuals under the direct influence of the environment. This is an omission of the same magnitude as if he had discussed organic variation in general without distinguishing between the inherited potentialities of the organism and their reaction to the influences of the environment.

Spencer covers both questions with the same formula, and this renders the argument confused from the outset, as the two questions are wholly distinct. Under no circumstances could the fertility of a horse equal the normal fertility of a rabbit. The potential fertility of each species will be adjusted to its needs during the evolution of the type and handed down by heredity. The variation of the actual degree of fertility will be decided by the direct action of the environment.

Spencer also put forward his theory as an explanation of both sexual and asexual genesis. He quotes the case

of aphides, for instance, as confirmation of his theory, and sees no significance in the fact that asexual reproduction is favoured by abundant nutrition, whereas it is scarcity that leads to sexual genesis. He entirely fails to realise that the two methods of reproduction are adapted to different conditions of life, acquire their full development at different stages of evolution, are governed by different principles, and usually react in diametrically opposite fashion to the same conditions.

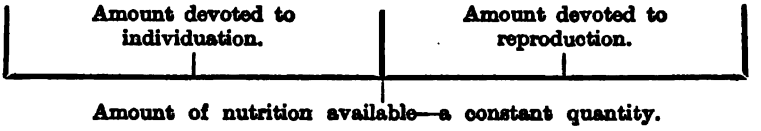
Spencer also brings within the scope of his formula the part played by instinct in reproduction. Genesis is surrounded by a complex body of instinctive associations, particularly in the case of the lower animals, which determine at what periods of the year and how often during the year the species shall breed. These instincts are hereditary and regulate the function of reproduction, so that the young may be produced during the period of the year most favourable to the species. Owing to the varying length of the period of gestation, it is necessary that coupling should take place at different periods of the year among different species. It is useless to attempt to explain these instincts by a simple physiological reaction, as some species couple in summer and some in winter, some during the season of plenty and some during the season of scarcity, the time being determined, not by the conditions of the moment, but by the necessity of producing the young at certain favourable periods of the year, and instinct is the guide.

The theory of Spencer is that the degree of fertility varies inversely with the cost of individuation. It is a curious fact that the literal meaning of this formula is the reverse of that put upon it by Spencer himself. For Spencer assumes that on his hypothesis a well-fed organism will be more fertile than an ill-fed organism. But surely the amount devoted to individuation is greater in a well-nourished

organism than in one that is ill-nourished. Therefore, if the degree of fertility is to bear an inverse proportion to the cost of individuation, a well-nourished organism, whose individuation has cost more, should be less fertile.

The formula is put forward as an explanation of the law which governs fertility. We must, therefore, take it that the amount of nutrition devoted to individuation determines what amount shall be devoted to reproduction, and not vice versa; for in the latter case the law governing fertility would remain unexplained. Therefore a well-nourished organism representing a higher cost of individuation should show a lower degree of fertility.

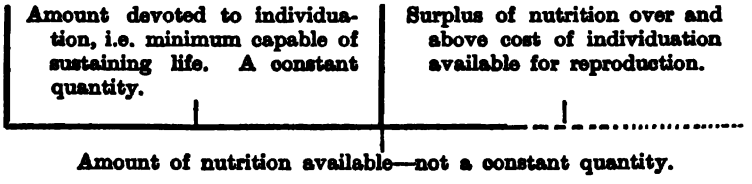
The fact is that Spencer had not accurately grasped the meaning of his own formula, or rather had not correctly formulated his own meaning. Although he puts forward the proposition that the degree of fertility will vary inversely with the cost of individuation, yet throughout his argument he really means and endeavours to prove that the degree of fertility will vary directly with the surplus of nutrition over and above the cost of individuation. These propositions are wholly different. Spencer confounded the two. The inverse ratio between fertility and the cost of individuation may be shown thus:—



It will be noted that the above diagram, as is the case with Spencer's formula, assumes the amount of nutrition available to be a constant quantity. On this assumption the amount devoted to reproduction must necessarily decrease as the amount devoted to individuation increases. As the formula purports to be an explanation of the law governing fertility, the amount devoted to individuation

must be the governing factor. Therefore the cost of individuation being higher in a well-nourished organism, such an organism should be less fertile, not more fertile, as Spencer assumed.

But the amount of nutrition available is not a constant quantity, so there is no necessary inverse ratio between reproduction and individuation. What Spencer really meant may be shown thus :—



We may attach either of two meanings to the phrase "cost of individuation." We may take it to mean the gross amount devoted to individuation and used for building and maintaining the body of the organism; or we may take it to mean the minimum amount which is capable of sustaining the life of the organism. By the amount of nutrition available we must understand, not the gross amount lying loose in the environment, but the amount which the organism can assimilate. If we assume the "cost of individuation" to be the gross amount assimilated, then an inverse proportion between individuation and reproduction would mean that a well-fed organism would be less fertile than an ill-fed organism. But if we take the phrase to mean the minimum amount capable of sustaining life, then we may assume that any surplus would be available for the purposes of reproduction. But this would be a direct ratio with the amount of nutrition available over and above the cost of individuation, not an inverse ratio with the cost of individuation.

If we glance along the ascending grade of types from unicellular organisms up to man, or, better still, to such

bulky organisms as the horse or the elephant, we can perceive that Spencer's formula is a rough but inadequate expression of the broad results of organic evolution. The bigger the organism the less, as a rule, will its fertility be. But it is quite inadequate as an expression of the facts,[1] as a few simple illustrations will show. "The condor lays a couple of eggs and the ostrich a score, and yet in the same country the condor may be the more numerous of the two; the fulmar petrel lays but one egg, yet it is believed to be the most numerous bird in the world. One fly deposits hundreds of eggs, and another, like the Hippobosca, a single one."[2] Compare also the difference between the fertility of the wild pigeon and the pheasant.

The formula has no application to the variation of the degree of fertility under the direct influence of the environment. The minimum amount necessary to sustain the organism would be a fairly constant quantity throughout life after maturity. Therefore there could be no inverse ratio, since there would be little or no variation. While, if we assume the phrase "cost of individuation" to apply to the gross quantity of nutriment assimilated by the organism, then the meaning of the formula would be the reverse of that put upon it by Spencer.

Throughout Spencer's argument his meaning is extremely nebulous, and varies constantly to suit the exigencies of the evidence. The following passage illustrates this, and shows also that the above explanation of his real meaning is correct. "Thus the strength of the blackbird opens to it a store of good food much of which is inaccessible to so small and weak a bird as a linnet, a store especially helpful to it during the cold months when the hibernating snails in hedge bottoms yield it abundant provision. The result is that the blackbird is ready to breed very early in the spring, and is able during

[1] See p. 38. [2] *Origin of Species*. Darwin, chap. iii.

the summer to rear a second and even a third brood. Here, then, a higher degree of individuation receives advantages so great as to more than compensate its cost. It is not that the decline of genesis is less than proportionate to the increase of individuation, but there is no decline at all." [1]

Spencer admits here that a bulkier organism should, on his own theory, be less fertile than an organism of less bulk. Obviously, then, if the formula is to be taken literally, a well-nourished animal or bird should be less fertile than one which is ill-nourished, since its greater bulk represents a greater cost of individuation. He admits that the larger blackbird is as fertile as or more fertile than the linnet, and he meets this by arguing that the increased cost of individuation in the blackbird is more than compensated by an increased food supply. In other words, he argues that the degree of fertility varies directly with the surplus of nutrition over and above the cost of individuation, thus changing his meaning to suit the exigencies of the evidence. Spencer did not even attempt to explain what factor determines the amount of nutrition to be devoted to individuation and reproduction respectively, and to this omission much of the confusion of thought is due.

Considered as a generalisation covering the variation in the potential degree of fertility as between species and species, Spencer's formula is an inadequate expression of the facts. If a species is to survive and evolve, its degree of fertility must vary inversely with its capacity for survival. The cost of individuation, which is measured mainly by the bulk of the organism, is only one factor making for survival, and by no means the most important.

Neither the formula put forward by Spencer, nor the one which we have seen expresses his real meaning, has

[1] *Principles of Biology*, Spencer, vol. ii, part vi.

any application to the variation in the degree of sexual fertility under the direct influence of the environment. The evidence relating to this part of the subject has already been fully discussed, and need not be repeated here.

The formula which has been given as expressing Spencer's real meaning may fairly be applied to asexual reproduction. For we have seen that asexual reproduction is favoured by abundant nutrition. But there is no inverse proportion, as the amount devoted to individuation is not necessarily decreased when the amount devoted to reproduction increases. It is when the organism is possessed of an abundance of nutrition over and above the amount necessary to maintain the individual—more than can profitably be assimilated without further growth —that asexual reproduction is most abundant. In fact, the amount devoted to reproduction appears to be at its highest when the amount devoted to individuation is also at its highest, and the organism has more nutriment than it can utilise for its own purposes. Therefore we may justly say that the degree of asexual fertility is directly proportional to the surplus of nutrition over and above the cost of individuation.

The reader may perhaps ask: Does not Spencer provide a very large body of evidence in support of his hypothesis? He does. But it consists of facts drawn from asexual reproduction, the truth about which has been set forth above; of evidence drawn from the comparative fertility of different species, to which we have seen that that formula is inadequate as an expression of the facts; and of evidence drawn from the relative fertility of wild and domesticated varieties, which we have seen will be modified by the selection of the latter. None of this evidence has any bearing on the variation of the degree of sexual fertility under the direct influence of the environment. When all this is subtracted, the amount of evidence

left is of very modest dimensions, and Spencer's dealing with the residue is remarkable.

In dealing with domesticated animals he fails to grasp the fact that the condition of the animal at the time of copulation is the decisive factor. The infertility of wild animals when highly fed in captivity is dismissed in a footnote with the suggestion that it may be due to improper feeding. The infertility of wild plants when cultivated in gardens and hothouses is not mentioned. The relative infertility of the wealthier and more highly fed classes in human society is flimsily attributed to their "high pressure education" and the "overtaxing of their brains." The enormous fecundity of the poor populations of Russia, China, Japan and India is not even mentioned, though in itself a conclusive refutation of Spencer's theory. The current assumption that the lowest races contrive, in some miraculous fashion, to combine an enormous deathrate with an exceptionally low birthrate is accepted without question. The French-Canadians are represented as living in a country where the necessaries of life are easily obtained, the truth being that they are an ignorant and backward race of peasant farmers living in a country which is covered with snow for some five months in the year, paying tithes to a tyrannical priesthood, having a standard of living "lower than that of the Irish or Italians," and earning their living like peasant farmers the world over, by hard physical toil, in which, no doubt, their wives take a substantial share. Lastly, the Irish are represented as receiving an exceptionally large return for a moderate expenditure of labour. Rack-renting and similar details are not noticed. Yet one of the characters in *John Bull's Other Island* declares that "an Irish peasant's industry is not human: it's worse than the industry of a coral insect. An Englishman has some sense about work:

he never does more than he can help—and hard enough to get him to do that without scamping it; but an Irishman will work as if he'd die the moment he stopped."

When the classes of evidence which have no bearing on the variation in the degree of sexual fertility under the direct influence of the environment are put aside, and when the evidence which has been distorted by special pleading has been readjusted to its proper perspective, the amount of evidence in favour of Spencer's theory is microscopical.

In an appendix to vol. i. of his *Principles of Biology* Spencer gives what is really a much better attempt at a scientific theory of animal fertility than the theory criticised above. The essence of it is contained in the following extract:—

"We found it to be the necessary law of the maintenance of races that the ability to maintain individual life and the ability to multiply vary inversely. But the ability to maintain individual life *is in all cases measured by the development of the nervous system.* If it be in a good visceral organisation that the power of self-preservation is shown, this implies some corresponding nervous apparatus to secure sufficient food. If it be in strength, there must be a provision of nerves and nervous centres answering to the size of the muscles. If it be in swiftness and agility, a proportionate development of the cerebellum is presupposed. If it be in intelligence, this varies with the size of the cerebrum. . . . Hence the nervous system becomes the universal measure of the degree of co-ordination of actions, that is, of the life or the ability to maintain life. And if the nervous system varies directly as the ability to maintain life, it must vary inversely as the ability to multiply." [1]

[1] *Principles of Biology*, Spencer, vol i, Appendix A.

Thus Spencer clearly grasps the fact that fertility must, in the long run, vary inversely with the survival-capacity of the species, and he argues from this that it must vary inversely with the mass of the nervous system. This is a much closer approximation to the truth, but he again fails to analyse accurately the essential factors of the problem. He again fails to distinguish between the variation in the inherited potential degree of fertility as between species and species and the variation in the actual degree of fertility under the direct influence of the environment. Let us consider the theory in its relation to the first problem.

It is true that cerebral development is the most powerful factor making for survival, but it is not the only factor. Organs of locomotion, weapons of offence and defence, and many other factors play a part. It is no doubt true that each of these factors implies a corresponding development of nerves and nervous centres, but the bulk of the nervous development will not necessarily correspond with their life-preserving efficiency. The skunk, for example, has the power of ejecting an intolerably evil-smelling fluid over its enemies. So overpowering is the stench, that the animal is usually left severely alone. It is obvious that the necessary nervous development would not correspond in bulk with the life-preserving power of such a weapon. Moreover, the character of the environment is of not less importance than the character of the organism. Some organisms are much more favoured by their environment and habits of life than others. The brown rat is probably a more powerful and cunning animal than the water rat. But it lives in an environment which leads to a heavy deathrate. The water rat, living almost unmolested along the banks of streams, can maintain its numbers with a very low rate of reproduction. The brown rat, living among the habitations

of man and regarded as a nuisance, is fiercely persecuted. It consequently needs an enormous rate of reproduction to maintain the species.

The difference in the degree of fertility between the wild pigeon and the pheasant or partridge cannot be said to bear an inverse proportion to the difference in the bulk of their nervous systems. Yet it represents fairly accurately the difference in the survival-capacity of the species owing to the greater flying powers of the pigeon. Therefore, the mass of the nervous system is not a reliable measure of the survival-capacity of a species, but the rate of reproduction must, and does, vary inversely with the latter. Again, it may be pointed out that the inherited potential degree of fertility will be decided by the laws of variation and adaptation which govern the rest of organic evolution.

The mass of the nervous system cannot possibly act as a measure of the variations of either the survival-capacity or the reproductive capacity from day to day. After the reproductive period has been reached, the ratio between the nervous system and the rest of the organism will remain fairly constant throughout life. The variations in the survival-capacity of organisms can only be measured by a factor which varies also. Had Spencer analysed the factors of the problem a little more closely, he might have stumbled on the hypothesis set forth in this work and found such a varying factor *within* the nervous system in the form of nervous energy.

CHAPTER XII

DOUBLEDAY'S THEORY AND RECENT EXPERIMENTS

I WAS fortunate enough some time ago to come across an old copy of the now almost forgotten work of Thomas Doubleday on *The True Law of Population*. My previous knowledge of the work had been confined to a brief criticism of Doubleday's theory by Herbert Spencer in a footnote to his *Principles of Biology*. Never seeing the theory mentioned elsewhere, I had attached no importance to it. And probably the work is known to very few students of the problem of the birthrate, since they are not likely to become acquainted with the theory unless they come across a copy of the book. It is but fair to Thomas Doubleday to point out that as far back as the year 1841, and even earlier in *Blackwood's Magazine* for March 1837, in an article under the title "A Letter to The Right Honourable Lord Brougham," he had perceived and stated that the rise in the birthrate about that period was closely connected with the fall in the standard of living. And his argument distinctly implied that the only way to check the excessively heavy birthrate was to improve the condition of the mass of the people.

Malthus had recently developed his famous theory that the evils from which society suffers are, in the absence of sexual restraint, necessary to keep down the numbers of the population. Doubleday retorted that these evils were the cause of the heavy birthrate, and that the chief

danger from an improvement in the condition of the people is not over-population but de-population. Some eighty years have passed since then, and Doubleday has been completely justified. Yet, while the name of Malthus is familiar to every social student, the name of Doubleday is almost unknown. Therefore it will be no more than justice to devote a few pages to a criticism of Doubleday's theory, showing its strong and weak points, and emphasising the fact that he was probably right in his main contention, although his theory was ill formulated.

Doubleday argued that when the existence of a species is endangered, "a corresponding effort is invariably made by Nature for its preservation and continuance by an increase of fertility, and that this especially takes place whenever such danger arises from a diminution of proper nourishment or food, so that consequently the state of depletion or the deplethoric state is favourable to fertility, and that, on the other hand, the plethoric state, or state of repletion, is unfavourable to fertility in the ratio of the intensity of each state."

The chief defects in this statement of the law governing the variation in the degree of fertility under the influence of the environment are two. In the first instance it is asserted that the degree of fertility will vary in the ratio of the intensity of the two states. This implies that the less the amount of nourishment the greater the degree of fertility. But such a result is obviously impossible. According to this formula the greatest degree of fertility would be reached in an absolutely barren soil, whereas there could be no fertility at all in such circumstances. But given a small amount of nutrition, then a certain degree of fertility may appear. This will increase in a direct ratio with the amount of nutrition up to the point where the maximum degree of fertility is developed. It is only when the amount of nutriment suitable for

developing the maximum degree of fertility has been exceeded that such a formula has any application.

Doubleday was not unaware of this. He conducted a series of experiments to ascertain the effects of various kinds of manures on plants and their fertility. As a result he came to the conclusion that, "whatever might be the principle of manure, *an overdose* of it invariably induced sterility in the plant." Thus he admits in this passage that it is only an overdose which induces sterility. Unfortunately, he only embodied half the truth in his formula. What resulted was this: whilst Doubleday insisted upon one half of the truth and ignored the other half, Spencer, Darwin, and the rest of his critics were careful to insist upon that half of the truth which he had left out of his formula, and to ignore as far as possible the half upon which he insisted. It was, of course, quite easy under the circumstances to quote a hundred facts which apparently gave a flat contradiction to Doubleday's formula.

The second defect is that, as stated, the formula gives too great a weight to one factor in the environment to the exclusion of the rest. There are innumerable other factors in the environment which affect fertility besides food, and these must act through the medium of some factor in the organism which is not specified in the formula. Although Doubleday seemed to recognise that other factors affect the degree of fertility, yet he deals almost exclusively with the effects of variations in the food supply. Food has unquestionably a great effect upon the degree of fertility, especially among the lower animals and plants, but the figures previously given showing the enormous proportion of completely infertile marriages among the intellectual classes seem to show that cerebral development resulting from intellectual and athletic exercises is of still greater influence in producing sterility among

human beings. Therefore Doubleday's formula is quite inadequate as an expression of the facts.

The last chapter of Doubleday's book, however, is a really remarkable one when read in the light of experimental results obtained by scientists in recent years. A series of experiments to test the action of various manures on plants led Doubleday to the conclusion that "all substances that contain portions, that is to say sensible or considerable portions, of alkali in combination with their other constituents may be expected to act, and will, generally speaking, act as manures." He further concluded as the result of his experiments that "the alkali when it acts as a stimulant is *caustic*, or in part so." Finally he came to the conclusion that "caustic and pure alkali is the basis, or rather the stimulating principle of manure. It is the principle which causes the seed to expand, the plant to push, and the work of vegetable growth to proceed." He further adds: "Pursuing the inquiry upwards from the vegetable to the animal kingdom, the next question is—may not that which stimulates the seed into life stimulate the *egg* into life; and may not one law here run throughout nature?" In answer to this inquiry there are certainly some facts which speak strongly in the affirmative, and these are, that alkali, that is to say *soda*, is found in the albumen of the eggs of birds, and also, in company with *ammonia*, in the "liquor seminalis" of animals, including man. Fourcroy, in his analysis of the "liquor seminalis" of a healthy man, detected both caustic soda and ammonia in quantity; and since his time the presence of active alkali in this secretion has been placed beyond all doubt or question.

So much then for the hypothesis. During recent years a large variety of most significant experiments have been carried out by Loeb, Delage and many other scientists on artificial parthenogenesis and the cross-fertilisation of

different species. They find that if a small quantity of some alkali, such as sodium hydroxide, be added to the sea-water in which certain species live, the degree of fertilisability is so raised that even widely separated marine species can fertilise each other. Sea-urchins and starfish, or even sea-urchins and molluscs can be crossed, and will produce hybrids which transmit the character of the female. With the aid of an alkali, salt, or sugar, it is also possible to secure artificial parthenogenesis in species whose normal mode of reproduction is sexual, and the resulting larvæ develop normally and live as long as the offspring from fertilised eggs. The facts in regard to alkali certainly provide astonishing confirmation of a hypothesis published eighty years ago.

Doubleday also suggested that "the neutralisation or absence of alkali in the male animal constitution would be a direct cause of sterility, and its decided presence, *e contrario*, a cause of fruitfulness, supposing in such case the female to be prolific by constitution." He then pointed out that the tendency of a plethoric diet is to produce an abundance of acid in the body, as seen in cases of gout, and that the tendency of too poor and scanty a diet is to develop an alkalescent state, as seen in scurvy, a disease produced by deficient and unwholesome diet. It is well established that acid is fatal to the germ cells, perhaps through neutralising the alkali, but an excess of alkali seems to be equally fatal. Probably there is an optimum point for this as for other factors.

This work of Thomas Doubleday was a most valuable contribution to the study of the problem of the birthrate and the laws which govern fertility. But, as not infrequently happens, he was completely baffled by the blindness of his contemporaries. They were infatuated by the theory of Malthus, who had provided them with an admirable excuse for their selfishness, and were most

unwilling to listen to a writer who would have urged upon them the necessity of social reform, instead of laying the blame for the evils from which society suffers at the door of Providence. It will be no more than justice if we divert a little of the attention which is bestowed upon the work of the man who was wrong to the work of the man whom time has substantially justified. The present belief that the birthrate is regulated by the use of contraceptives would have been meaningless to Doubleday. He was dealing with an increase. The only way in which the race-suicide theory could be applied to such facts would be to assume that the people were formerly in the habit of limiting the size of their families by the use of contraceptives, but were now giving up the practice, or rather were now content to rear substantially larger families than before for no better reason than that they were less able to support them.

Unlike his opponents, Doubleday could not ignore the increase or assume it to be an effect without a cause. To him, seeing that the increase accompanied a lowering of the standard of comfort which resulted from the introduction of the factory system, it was an obvious inference that the best way to cause a decrease was to reverse the conditions which brought about the increase. He illustrated this by many historical facts, showing that exceptionally prosperous periods were accompanied, not by over-population, but by de-population. Time has justified his view. A reversal of the conditions which brought about the increased birthrate has caused a decrease. And a further accentuation of the causes which have brought about the decrease should produce a further decline.

CHAPTER XIII

THE FUTURE

Two parties are conspicuous in the constant controversy which rages round the question of the desirability of birth control. There is the party the members of which seem to be anxious for population at any price, and close their eyes to the fact that a full realisation of the potential fertility of the race would lead to disastrous over-population in a few generations, besides the blighting effect of large families upon the fortunes of the poor. There is the opposite party, the members of which see these things vividly, but are blind to the equally obvious fact that if the decline in the birthrate continues unchecked, then in a few years' time births will be insufficient to balance the deaths, and a decline must occur in the populations affected similar to that which took place in Ancient Rome and Greece. To France the problem of the birthrate has already become a matter of life and death. But for the influx of fertile Italians and others it is probable that her population would be already on the decline. A replacement of its population by foreign immigrants is a prospect which no virile and patriotic nation can view with equanimity.

What we need is an intelligently regulated birthrate. We need to obtain the largest possible proportion of children from the ablest sections of the people, and the smallest possible proportion from the unfit. We need such a rate of reproduction as shall provide for the upkeep

of our own population, and also yield a suitable margin for emigration to the colonies which are in need of population. But at present our birthrate is utterly unregulated. We are obtaining the largest proportion of children from the least fit, and the smallest proportion from the ablest sections of the population. And all through human history the spectacle has been one of periods of gross over-reproduction, with disastrous economic consequences, alternating with periods of under-reproduction and depopulation.

To obtain an intelligently regulated birthrate, we must first acquire a clear insight into the laws which govern fertility, and devise some means of overcoming at will the rapidly increasing sterility now making itself manifest through all classes. Seeing that such vast increases in the fertilising power of the sperm cells and in the fertilisability of the egg cells can be obtained by such slight and simple means as shown in the experiments of Loeb and others, the possibility that we may find some simple means of ensuring fertilisation in the case of human beings is by no means a forlorn hope. The task may prove unexpectedly easy. It seems to be merely a matter of bringing these influences temporarily to bear on the germ cells.

Probably the most hopeful way of influencing the germ cells is through the medium of the blood. As their nutritive condition will no doubt be determined by the quantity and quality of the blood supply, it is desirable that we should know the effect on fertility of an increase of the alkalinity, acidity, and salinity of the blood. This should be readily ascertainable by means of simple and harmless experiments on unicellular organisms and the lower animals.

There are in the body certain glands which secrete

and pour into the system various fluids known as "hormones." Comparatively little is yet understood of the work of these glands, but enough has been ascertained to prove that their functions are very important. The injection into the blood of extracts obtained from them has produced most remarkable results. Goitre is reduced, as a rule, by the injection of extract of the thyroid gland. A singular result is the development of a cock's comb on the head of a hen as the result of injecting testicular extract. These glands, in fact, seem to control the growth and functions of the various organs. Now, as the nutritive condition of the germ cells is probably governed by the central nervous system through the medium of the blood, and as these glands which pour their secretions into the system must also be controlled by the nervous system, it seems fairly clear that we have in these three, the nervous system, the glands, and the circulatory system, the great regulating mechanism of the organism. Probably the whole metabolism and development of the organism from childhood to old age is controlled by the acceleration or retardation of the work of these glands. And it is not improbable, therefore, that the secretions of some of them play a powerful part in the nourishment of the germ cells, and thus regulate fertility.

Another factor to be studied is that presented by the constituents of food known as "vitamines." Experiments have shown that if fowls are fed on polished rice or other foods deficient in vitamines, they fall victims after a period to beri-beri and other diseases; while if vitamine starvation be carried far enough death ensues. We need some intelligently directed experiments to ascertain the effects of both a deficiency and a superabundant supply of vitamines on fertility. Not a great deal has been done in this direction yet. McCarrison has

found that "an exclusive diet of milled rice causes, after about thirty days, a complete suppression of the function of spermatogenesis," and also that "one of the most remarkable results of a dietary deficient in so-called 'anti-neuritic' vitamines is the constant and very pronounced atrophy of the testicles in males and the similar but less pronounced atrophy of the ovaries in females."[1] But what is most important to ascertain is whether there is an optimum point for fertility with these vitamines as with other food factors.

Some interesting possibilities are suggested by the following passage from *Buchan's Domestic Medicine*, published in 1813, or over a hundred years ago, and it is significant to note that the same influences which are at work in an accentuated form to-day had been noticed even then, and that some of the most promising remedies were also known. "It is very certain that high living vitiates the humours and prevents fecundity. We seldom find a barren woman amongst the poor, while nothing is more common among the rich and affluent. The inhabitants of every country are prolific in proportion to their poverty; and it would be an easy matter to adduce many instances of women who, by being reduced to living entirely upon milk and vegetable diet, have conceived and brought forth children, though they never had any before. Would the rich use the same sort of food and exercise as the better sort of peasants, they would seldom have any cause to envy their poor vassals and dependents the blessings of a numerous and healthy offspring, while they pine in sorrow for want of a single heir to their extensive domains.

"Affluence begets indolence, which not only vitiates

[1] *Indian Journal of Medical Research*, Robert McCarrison, January, 1919.

the humours, but induces a general relaxation of the solids, a state highly unfavourable to procreation. To remove this we recommend the following course: First, sufficient exercise in the open air; secondly, a diet consisting chiefly of milk and vegetables; thirdly, the use of astringent medicines as steel, alum, dragon's blood, elixir of vitriol, the Spa or Tunbridge Waters, Peruvian bark, etc., and lastly, above all, the cold bath."

Verily there is nothing new under the sun. Here in this old volume of over a hundred years ago we have the main symptoms of the birthrate problem clearly grasped and the most promising lines of treatment mapped out. Iron is strongly recommended by Sharp in his *Essays on Medicine* as "greatly facilitating conception." If iron in small quantities or any of the other substances recommended do really facilitate conception, it is easy to see how many of the apparently contradictory statistical results could be produced. Suppose the water of a given district strongly impregnated with iron. This might lead to a considerable increase of average fertility in that district. In another district might be present some substance which tended to check fertility. As it is not likely that any material effect on the deathrate would result in either case, there would be a considerable irregularity when birthrates and deathrates of the two districts were compared. Yet for a country as a whole the law of averages would level up these incidental factors.

A very interesting line of inquiry is suggested by "some results obtained at the experimental farm at Roseville, California, by Professor Silas Wentworth, who has found that by placing ewes in a field under the power wires of an electric power company, the average production of lambs is more than doubled." [1] Assuming the fact

[1] *The Task of Social Hygiene*, Havelock Ellis, p. 173.

to be authentic, it would seem that the power wires produced an electrically charged atmosphere in the immediate neighbourhood, and this may have affected the reproductive powers through the nervous systems of the sheep. Perhaps it had an enervating effect similar to that produced by the electrical condition of the atmosphere which precedes a thunderstorm.

In addition to a careful study of the effect of all the nutritive factors of the environment upon fertility, we need a systematic inquiry into the effects of intellectual activity. A good deal of striking evidence has already been given, but we need much more far-reaching and systematic inquiries than have yet been carried out. Obviously the proportion of completely sterile marriages offers the best test both for this and for the general question whether there has been a great decline of fertility due to natural causes. Thus far there have been no adequate statistical inquiries directed to this end. Some significant facts have been given earlier in this work. More figures are given in the Report of the National Birthrate Commission, but they are scrappy and not arranged to throw any real light on the relative proportion of completely sterile marriages in comparisons between different countries, different periods and different social classes, which is the kind of information needed. For example, "sterility is much more frequent among American women than among foreign women in America. Among various groups in Boston, St. Louis and elsewhere, it varies between 20 and 23 per cent., and in some smaller groups is even considerably higher, while among foreign women it is only 13 per cent."[1] It may be added that the average fertility of native American women is considerably less than that of foreign-born women. Malthus quotes

[1] *The Task of Social Hygiene*, Havelock Ellis, p. 173.

M. Muret to the effect that the number of childless married women at Vevay, Switzerland, at the end of the eighteenth century was only 20 out of 478, or little more than 4 per cent.[1] If we find that there is a proportionate rise in the percentage of completely sterile marriages in other comparisons, we are bound to conclude, unless we are prepared to accept the grotesque caricature of the "demographic woman," that there has been a vast decline of natural fertility; and if this is particularly marked among the intellectual classes, it will be a fair inference that the great spread of education and cerebral activity has been a powerful contributing cause. These factors appear to produce a state of nervous tension which is inimical to fertility.

Many most promising lines of inquiry and experiment are opened up by the hypotheses and generalisations herein sketched out. And it is only by the systematic following up of these inquiries that the problem of the birthrate can be successfully grappled with. Eloquent exhortations and denunciations are alike useless. Only an accurate understanding of the problem will enable us to deal with it. And this understanding will have to include a solution of the economic problems involved. So long as Society is run upon the principle of every man for himself and the devil take the hindmost, so long will this principle manifest itself in the problem of the birthrate. Whether the decline be due to contraceptives or to natural causes, it will be equally useless to exhort the abler sections of the community to produce a number of children adequate to maintain the numbers of the population unless there is some economic guarantee that they shall not be hopelessly penalised in the race thereby, and if they should break down in the struggle be left to starve in the gutter.

[1] *The Principle of Population*, Book II, chap. v.

So stupendous economic problems have to be grappled with in the near future.

But let us assume that the power to secure fertilisation at will is achieved, and that the economic problems involved can also be successfully dealt with. It will then be necessary to classify the population according to ability. From the class of highest all-round efficiency, both mental and physical, we should desire the largest proportion of children; from the class next in order of efficiency a smaller proportion; and so on in a diminishing proportion until we reach the unfit, from whom we should desire as few children as possible. There would be no need for a stud farm system or a special selection for special points. The only selection needed would be for general efficiency, and Nature could then be left to design her own superman. But to obtain these results it would be necessary to approach each married couple individually for a given number of children at carefully regulated intervals, and assent would only be obtained if the necessary economic guarantees could be given. These conditions being granted, there would be little fear of a refusal in the vast majority of cases in a healthily organised society. Public opinion is a powerful force, selection to assist in the continuation of the race would be one of the highest compliments Society could bestow, and a clear realisation of all the bearings of the problem would do the rest.

The hypotheses which have been worked out may be briefly summarised. They are:—

(1) That the decline in the birthrate is mainly due to a natural law which adjusts the degree of fertility to suit the deathrate of the race.

(2) That the variation in the degree of animal fertility in response to the direct action of the environ-

ment will bear an inverse proportion to the intensity of the nervous charge (for the sake of simplicity we may ignore the qualification when discussing the application of the principle to human society, as it will only come into operation under famine conditions).

(3) That the principle is a law governing the union of sperm cell and ovum.

The first of these hypotheses has no necessary dependence on the second, and the second has no necessary dependence on the third. Although the evidence in favour of all three theories is very strong, yet they are put forward as hypotheses merely, not as complete and final explanations. The writer is content to regard this work as a case for a further inquiry, certain that even if an energetic following up of the lines of inquiry sketched out should lead to the overthrow of the hypotheses in question, yet by the time these are shown to be wrong some other theories will have been shown to be correct.

It will be useful in conclusion to sketch out the theory of sexual fertility as a whole. It has nothing to do with the variation of the inherited potential degree of fertility as between species and species, but is a theory of the law which governs the degree of sexual fertility of individuals under the direct influence of the environment. It has nothing to do with asexual fertility, which appears to vary directly with the surplus of nutrition over and above the cost of individuation. The presumption is that the degree of fertility is mainly dependent on the nutritive condition of the germ cells, and that this is governed by the central nervous system through the medium of the circulatory system, and probably by hormones secreted by certain glands and poured into the system. The theory is expressed in the formula

that the degree of fertility will be directly proportional to the development of nervous energy until the optimum point for fertility is reached, and will thenceforward vary inversely with the development of nervous energy. The formula must be taken as applying to that condition of the nerves which favours the discharge of energy, and this condition will represent the net result of nutrition and activity, or balance between accumulation and expenditure.

As thus stated, the theory is a working hypothesis, and is merely the best statement of the law of nervous action in this matter that our almost complete ignorance of what goes on in the nerve permits us to make. Its value lies in this, that it produces order out of the chaos of apparently contradictory facts, and enables us to conduct intelligently directed inquiries instead of groping blindly in the dark. It will be subject to restatement in the light of fuller knowledge, and when it can be replaced by a better statement, the quicker it is flung upon the scrap-heap the better.

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